DIVISION IV: STARS
Étoiles

PRESIDENT: Dainis Dravins
ORGANIZING COMMITTEE: Beatriz Barbuy,
Christopher Corbally, Wojciech Dziembowski, William Hartkopf,
Christopher Sneden, Monique Spite

The IAU Division IV (‘Stars’) organizes astronomers studying the characteristics, interior and atmospheric structure, and evolution of stars of all masses, ages, and chemical compositions.

During the triennial starting at the Sydney General Assembly in August 2003, the following officials served in Division IV: President – Dainis Dravins (Lund, Sweden); Organizing Committee – Beatriz Barbuy (São Paulo, Brazil; former Div. IV president); Christopher Corbally (Vatican & Tucson, USA; Comm. 45 President); Wojciech Dziembowski (Warsaw, Poland; Comm. 35 President); William Hartkopf (Washington DC, USA; Comm. 26 President); Christopher Sneden (Austin, USA; Comm. 29 President), and Monique Spite (Paris-Meudon, France; Comm. 36 President).

1. IAU DIVISION IV

Division IV has its origins in the then new division structure that was introduced on a trial basis at the General Assembly in the Hague 1994, becoming formally accepted at the Kyoto General Assembly in 1997. Previous presidents of Division IV have been: David L. Lambert (Austin; 1994-1997), Lawrence Crum (Sydney; 1997-2000), and Beatriz Barbuy (São Paolo; 2000-2003).

The following five Commissions are part of Division IV:
Commission 26: Double and Multiple Stars (about 110 members)
Commission 29: Stellar Spectra (about 340 members)
Commission 35: Stellar Constitution (about 330 members)
Commission 36: Theory of Stellar Atmospheres (about 330 members)
Commission 45: Stellar Classification (about 130 members)

There are four Division Working Groups, of which two jointly with Division V – Working Group on Abundances in Red Giants; Working Group on Massive Stars; Joint Division IV/V Working Group on Active OB Stars, and Joint Division IV/V Working Group on Chemically Peculiar and Related Stars.


2. SCIENTIFIC MEETINGS

One of the main tasks of the Division (besides all the work within its Commissions!) has been to evaluate proposals for IAU meetings, and to advise the IAU Executive in their selection. Based upon the experience from this process (which in the past has not always been very simple nor straightforward), ideas for simplification were developed. Part of the problems was related to the traditional subdivision of astronomical topics within the IAU Commission and Division structure. Possibly, the Division ‘Stars’ has
3. CUTTING ACROSS DIVISION BOUNDARIES

The scientific interests of Div. IV have strong connections with those of some other Divisions, especially Div. V ('Variable Stars') with which it has two joint Working Groups. It also has a strong connection to Div. II ('Sun and Heliosphere') as well as Div. VII ('Galactic System').

Already in the first Div. IV triennial report (IAU Trans. XXIII A, 1997), the then Division president David L. Lambert noted how often a discovery spreads across Commission and Division boundaries.

For example, consider the study of stellar oscillations in 'ordinary' solar-type stars. Prime scientific aims concern the study of stellar atmospheres and interiors, thus clearly belonging to our Div. IV. However, since the study is of variability, might it not instead 'belong' to Div. V, 'Variable Stars'? However, on the observational precision levels now reached, virtually all stars are variable but surely not all stars are to be referred to that Division? Actually, much of this new stellar physics is basically an application of solar techniques, so the methods may more belong to Div. II, 'Sun and Heliosphere'. Or, come to think of it, since oscillation studies emerge from the development of methods for very precise measurements of apparent stellar radial velocity, would the topic better fit within Comm. 30 'Radial Velocities' and its Division IX, 'Optical and Infrared Techniques'?

The Div. IV Commission 26, 'Binary and Multiple Stars' has a Working Group on Binary and Multiple System Nomenclature, justified i.a. by the numerous different methods through which stellar companions are now being detected. Planetary-mass companions are being found close to their parent stars, while adaptive-optics and interferometric techniques reveal close companions, in the past not resolvable optically: where is the borderline (if any) to Comm. 42, 'Close Binary Stars' within Division V, 'Variable Stars'?

Such examples show that the partition between (especially) Divisions IV and V exists mainly for historical reasons.

4. REPORTS FROM COMMISSIONS AND WORKING GROUPS

Further information on stellar physics, including web addresses for the various Commissions and Working Groups are to be found in their respective reports. However, while electronic communication is rapid, so is the rate of change of electronic addresses. The addresses listed in the reports below were active at the time of writing; however many officials will change following the General Assembly in Prague, as will the web addresses for the various bodies. The reader is therefore advised to consult the IAU website http://www.iau.org for the most current links to various Divisions, Commissions, and Working Groups.

Dainis Dravins
President of Division IV
Commission 26: Double and Multiple Stars

PRESIDENT: W. I. Hartkopf
VICE-PRESIDENT: C. Allen
ORGANIZING COMMITTEE: J.A. Davis, F.C. Fekel, P. Lampens,

1. Introduction

While Commission 26 remains one of the smallest in the IAU, it maintains an active program which belies its size, as highlighted below. Further information on the commission may be found at our website: http://ad.usno.navy.mil/wds/ds1.html#iau. This site includes links to other sites and to major databases and catalogues, as well as bibliographies of recent double star papers, an archive of the Commission’s Information Circulars, and a list of upcoming meetings.

2. Meetings

2.1. IAU Colloquium 191

The most notable achievement of the past triennium was IAU Colloquium 191, The Environment and Evolution of Binary and Multiple Stars. This meeting was sponsored by Commission 26, with the support of Commissions 30, 34, 37 and 42; Division IV was the coordinating division. The meeting was held in honour of one of the pioneers of Mexican astronomy, Arcadio Poveda, and took place in the city of his birth, Mérida, Yucatán, in February, 2003. The principal sponsor within Mexico was the Universidad Nacional Autónoma de México, Instituto de Astronomía. The scientific organizing committee was chaired jointly by Christine Allen and Colin Scarfe, the local organizing committee by Christine Allen.

The meeting was attended by about eighty people from twenty-four countries, and continued a long tradition of successful topical meetings organized by Commission 26. Its topic was in part a sequel to IAU Symposium 200, which concentrated on binary star formation, extending to the role binaries’ environment plays in their subsequent evolution, and how they in turn affect that environment. A significant type of environment is that of a star cluster, and for clusters the meeting was a sequel to one that took place in Calgary, Canada in 1995. Now, of course, that subject has been extended with the detection of numerous binaries in nearby galaxies by means of major surveys or as byproducts of gravitational microlensing studies. Moreover, we are now discovering low-mass objects such as planets within binary systems; part of the meeting was concerned with their role.

The meeting was organized around eighteen invited talks, with contributed papers related to them; presented either orally or as posters. Ample time was provided for poster viewing, and for discussion following each oral presentation. The difficult task of summing up was ably handled, with wit and humour, by Edward Guinan.

Proceedings of the meeting were edited by Christine Allen and Colin Scarfe, and published as Volume 21 of Revista Mexicana de Astronomía y Astrofísica, Serie de Conferencias.
2.2. Multiple Stars Workshop

A workshop *Multiple stars across the H-R diagram* was organized by ESO and held in the summer of 2005 in Garching, Germany. It attracted 41 participants and concentrated on stellar systems with 3 and more components. Studies of young multiples and their formation mechanisms were at the focus of the Workshop, but other subjects included evolution of multiple systems and their components, special objects, statistics, observing techniques, and future programs. The meeting showed the relation of multiple-star studies to other areas of astrophysics such as stellar formation and evolution, planets, X-ray astronomy, etc., and the general importance of continuing research on multiple stars.

2.3. Dubrovnik Workshop

Significant developments on observational techniques were presented during the workshop *Spectroscopically and spatially resolving the components of close binary stars*, held in October 2003 in Dubrovnik. These developments concern, among other things, the very high angular resolution work on the orbits of binaries which gives a bridge between the traditional division of the closer spectroscopic and eclipsing binaries and the wider visual binaries. Other interesting techniques are adaptive optics imaging to complete orbits and speckle interferometry for angular separation to 0″/1. We can also mention the (very) long-baseline interferometer to be able to separate components close to a few mas (Hummel et al. 2004) and combinations of astrometry with spectroscopy (Pourbaix et al. 2004) or optical interferometry with lunar occultation (Richichi 2004). These new observational developments at the boundaries of the visual binary field, permit a better knowledge of the mass-luminosity relation based on visual binaries at the end of the main sequence (Henry 2004) and an advance on the formation model of the double and multiple systems.

The cross-correlation techniques applied to the determination of radial velocities of close double stars permits also the discovery of new triple systems, in the frontier of the visual multiple stars field. This technique, used in the frame of an international collaboration, is pertinent to obtain high quality masses of all components of the systems and permits the study of some aspects in the stellar evolution (Obiak et al. 2004).

2.4. Michelson Interferometry Summer School/Workshop

Workshops are organized each summer by the Michelson Science Center and usually held on the Caltech campus in Pasadena, CA. The 2002 and 2003 meetings concentrated on interferometry, with the 2004 meeting highlighting coronography and the 2005 meeting astrometry (with an “astrometry basics” seminar held at Yale University the previous week). These workshops are intended mainly for graduate students and postdoctoral researchers, and include tutorial lectures, informal conversation, and site visits to nearby interferometer facilities. Although these week-long events concentrate on equipment and techniques as they can be specifically applied to the challenge of extrasolar planet detection, ancillary astrophysical topics, such as the high-precision characterization of binary stars, figure prominently in the curricula associated with each school and workshop.

2.5. Symposium 240

During this triennium we successfully proposed a symposium entitled *Binary Stars as Critical Tools and Tests in Modern Astrophysics*, sponsored by Commissions 26 and 42 with support from 11 other commissions and working groups. This 3.5-day meeting will be held in conjunction with the 26th General Assembly in Prague, in August 2006.
3. Information Circulars

For many years the commission has published information circulars three times annually. Begun by Paul Muller and continued by Paul Couteau, the circulars are currently edited by J.A. Docoño and J.F. Ling of the Observatorio Astronómico “R.M. Aller” at the Universidad de Santiago de Compostela, Spain. Circulars are distributed to all commission members electronically, and also archived on the commission website. Ten circulars, numbered 147 to 156 inclusive, were published during the past triennium. Their contents are summarized below; see the website for a more thorough report.

New orbits and newly discovered double stars: A total of 185 new orbits were announced, 119 of them for objects north of the celestial equator, and 66 for southern systems. Numerous authors contributed orbits, with some appearing in every circular. Circular 156 listed discovery of a new system and #149 the rectification of another.

Publication lists: Circulars 149, 152 and 155 included lists of papers on double stars published in 2002, 2003 and 2004 respectively.

Obituaries: Circulars 155 and 156 carried obituaries of Geoffrey G. Douglass and Richard L. Walker, respectively, two distinguished former members of the commission.

Miscellaneous announcements and reports: Several circulars contained announcements, whose subject matter ranged from the publication of new catalogues, and revisions to older ones, to information on new telescopes and instruments. New amateur observing efforts were noted in Circulars 148 and 155, and a report of the Commission’s business meeting at the Sydney GA was published in Circular 151.

4. Catalogues and Journals

The U.S. Naval Observatory double star program maintains four astrometric and photometric catalogs, each of which has seen considerable growth during the past three years. These four catalogs are updated nightly on the USNO website.

The Washington Double Star Catalog is the principal repository for all published astrometry of visual binary and multiple stars. As of July 2005 the WDS contained about 710,000 mean measures of over 100,000 systems, a 20% increase in number of means in the past three years. The database also continues to be improved through correction of errors, removal of duplicate discovery designations and/or measures, determination of precise coordinates (completed at present for >96% of the systems), and determination of secondary proper motions. Observing lists are provided on demand for other observers.

As of July 2005, the Sixth Catalog of Orbits of Visual Binary Stars, included 1,850 orbits of 1,750 systems. The catalog was recently modified to include published formal errors, and reformatted to accommodate short-period orbits of close interferometric pairs.

The Fourth Catalog of Interferometric Measurements of Binary Stars currently includes 131,101 observations of 67,943 systems, increases of roughly 30% since July 2002.

The Second Photometric Magnitude Difference Catalog has grown by roughly a factor of three during the past triennium, and now includes 202,276 measures of 62,620 systems. Much of this increase has come though matches against the WDS and 2MASS databases.

An internal catalog of rectilinear elements has been created, with the aim of eventually posting it to the web as well. Recent studies have shown that these linear fits often yield more precise differential proper motions than are available elsewhere, due to the long time base of differential astrometry measures available in the WDS database.
The Catalogue of Orbits of Visual Double Stars and their Ephemerides, complementary to the USNO catalogues because of its somewhat different selection criteria, is maintained at the Universidad de Santiago de Compostela. Updates are posted regularly on their website and linked to the Commission’s webpage.

The Journal of Double Star Observations is a new web-based quarterly journal, begun in early 2005 by astronomers at the University of South Alabama. This page-charge free electronic-only publication is intended as a venue for both professionals and amateurs.

5. Speckle interferometry and other single-aperture high-resolution astrometry techniques

Several astrometry projects using speckle interferometry or adaptive optics were initiated or continued during the past triennium, as these techniques largely supplanted micrometry for obtaining differential astrometry of visual binaries.

E. Horch, W. van Altena, and collaborators have maintained an active speckle program using primarily the Wisconsin-Indiana-Yale-NOAO (WIYN) 3.5-m at Kitt Peak, Arizona. Their work in the last three years has focused primarily on characterization and use of CCD-based speckle imaging with the RIT-Yale Tip-tilt Speckle Imager (RYTSI), as well as follow-up observations of double stars discovered by Hipparcos.

RYTSI is a unique speckle imager that uses a large format CCD as a memory cache of many speckle images prior to full-frame readout. Through the use of two galvanometric scanning mirrors, the star image is moved in a serpentine step-and-expose pattern, with each exposure representing one speckle pattern. The RYTSI instrument was completed in June 2001, and has been successfully used at the WIYN Telescope on ten observing runs. The instrument was recently coupled with the Kitt Peak Mini-Mosaic CCD imager at WIYN, where as many as 900 speckle patterns were recorded before full frame readout of the chip. The method is reasonably efficient at 8-m and smaller class telescopes given current CCDs, and is compatible with improvements in CCD readout noise and speed.

CCD-based speckle has also been shown to retain magnitude difference information about close binaries, something that has proven elusive with intensified-CCDs. The UMass-Yale group has used the CCD method to measure Δm’s of a number of sub-arcsecond binary stars, many of which were discovered by Hipparcos. The results so far are in reasonably good agreement with Adaptive Optics results of ten Brummelaar and collaborators. This gives some real hope that an increasing number of “speckle” binaries will soon have well-determined magnitude differences in multiple bandpasses in addition to the precise relative astrometry for which speckle is famous. This would be an important step forward in using these stars as tests of stellar structure and evolution.

PISCO, another speckle camera dedicated to the study of binary stars, has been operational since January 2004 on the 1-meter Zeiss telescope of I.N.A.F. — Osservatorio Astronomico di Brera at Merate, Italy. PISCO was designed and built at Midi-Pyrénées Observatory (Toulouse) in the early 1990’s and used from 1993 to 1998 at the 2m Bernard Lyot telescope of the Pic du Midi Observatory. Due to a change of policy by the time-allocation committee, it was no longer used after 1998 for regular observations of visual binaries. A group of European astronomers involved in the study of binary stars with PISCO decided to look for a new host telescope on which PISCO could be mounted and operated on a regular basis. In November 2003, PISCO and the intensified CCD camera of Nice University were successfully installed at the Cassegrain focus of the Zeiss telescope in Merate and after a few weeks of tests it became fully operational in Janu-
ary 2004. Subsequent observations confirmed the possibility of observing visual binaries with separations down to 0.14" and with luminosity differences up to 4 magnitudes. Two papers (Scardia et al. 2005a, 2005b) have already resulted from the observations of 2004.

The speckle interferometry program also continues at the USNO. Most observations have been carried out on the USNO 26-inch refractor, with nearly 4,200 measures published or in press since mid-2002 (c.f., Mason et al. 2004a, 2004b), despite suspension of observing during much of 2004 as the historic Clark refractor underwent extensive electrical and mechanical upgrades. Much of this observing effort has been directed toward duplicity confirmations and observations of systems not measured for many years, as well as regular monitoring of potential orbit systems. The speckle camera continues to be used at other telescopes as well, including the KPNO and CTIO 4-meters and the 1.5m at the Naval Observatory’s Flagstaff Station.

In the past triennium, adaptive optics (AO) has produced impressive new results in the field of binary stars. For the first time, complete statistics of faint companions to massive (B,A-type) primaries has been pinpointed (Shatsky & Tokovinin 2002, Kouwenhoven et al. 2005). Binarity of M-dwarfs and brown dwarfs has been probed (e.g., Siegler et al. 2005) and revealed a telltale story of their formation. Bouy et al. (2004) determined a first dynamical mass of an L-dwarf. Large surveys of pre-main-sequence and even protostellar (Patience et al. 2003, Duchene et al. 2004) binaries are being conducted with AO. Patience et al. (2002) combined wide-field imaging, speckle, and AO to reveal two binaries and a triple among the first sample of exoplanet systems.

A search for faint companions to O stars was done using the AEOS 3.6m and AO system in I band. The search included all 143 stars within known O star systems that were accessible to AEOS. Of the 84 stars observed to date, 31 new and 24 previously known companions were measured, with companions found as close as 0.34" (Δm = 4) and a dynamic range of 10 magnitudes (as close as 2"; see Turner et al. 2003 and in preparation). While investigating atmospheric turbulence using AO and the AEOS telescope, several dozen binaries were observed at I, J, H, and K bands, reaching J-band Δm’s of 8 mag and discovering several faint new companions to known systems (Roberts et al. 2005).

Peter Tuthill and Jamie Lloyd have begun experiments combining an aperture mask with the Palomar AO system; this technique has shown great promise in improving both astrometric and especially photometric accuracy, with order of magnitude improvements in photometric precision reported.

6. Long-baseline interferometry

Long-baseline optical/infrared interferometry is developing into an important tool in binary and multiple star astrophysical research and the past three years has seen major progress. Particularly notable are the increasing application of combined interferometric and spectroscopic observations to determine individual masses of component stars and accurate distances to systems, thereby enabling critical tests of evolutionary stellar models, and the development of multi-aperture imaging of multiple systems. Highlights of the application of long-baseline interferometry to binary and multiple star research include:

A program to measure PMS binary systems is being carried out with the Keck Interferometer (Boden et al. 2005) with preliminary results for the B binary system of the quadruple system HD 98800 revealing significant differences from model predictions.

Accurate mass-luminosity and mass-radius relations for M dwarfs in the solar neighbourhood have been determined by combining adaptive optics image, radial velocity, and ESO Very Large Telescope Interferometer (VLTI) data (Delfosse et al. 2004).
Models of the evolution of metal poor stars have been tested by the combination of interferometric and spectroscopic data for the binary HD 185987 (Torres et al. 2002).

The Sydney University Stellar Interferometer (SUSI) has been used to determine the orbit of β Cen and, in combination with spectroscopy, the masses of the two β Cephei components have been shown to be less than those generally accepted for early B giant stars. An accurate distance to the system has been determined that differs significantly from the Hipparcos value (Davis et al. 2005).

In addition to a continuing programme of interferometric orbital determinations the Palomar Testbed Interferometer (PTI) now has a differential astrometric capability and this has been used to determine the mutual inclination of V819 Herculis triple system.

The three aperture Infrared/ Optical Telescope Array (IOTA) has been used to image the binary star Capella, the underlying binary of the prototypical colliding-wind source WR 140, and the Am components of λ Vir.

The Navy Prototype Optical Interferometer (NPOI) has achieved imaging with more than three separate telescopes for the first time with six-aperture imaging of the hierarchical triple η Vir, enabling the orbit of the close pair to be determined leading to a value for the mass ratio and the relative orbit inclination. NPOI and Mark III interferometric data have been combined with spectroscopic data to determine the distance to the binary star Atlas in the Pleiades. A survey for multiplicity amongst bright stars is being conducted with NPOI.

The CHARA Array was transformed from developmental effort to routinely operating facility during 2003-2004. A variety of observing programs have been undertaken, including oblateness and gravity darkening exhibited by rapidly rotating stars, diameters of M dwarfs, calibration of the Cepheid P-L relationship, survey of exoplanet systems for contamination by face-on binaries, stellar limb darkening, and a survey for companions to O stars. CHARA plans to undertake an extensive program of resolving double-lined spectroscopic binaries during 2006. In the interim, binary star studies have been limited to astrometry of “wide” binaries (separations 20–70 mas) that display separated fringe packets within a given fringe scan. Accuracies obtained thus far are approaching 25µas.

An additional application of separated fringe packets is the use of one packet to calibrate the interferometric visibility of the companion star if it is itself a spectroscopic binary; experiments are underway with the inner two subsystems of the hierarchical η Orionis quintuple system. In 2005 a prototype multi-beam combiner developed for the Array successfully combined four beams simultaneously measuring closure phases and, for the first time by an optical interferometer, closure amplitudes. This instrument will be expanded to six-way beam combination during 2006, permitting imaging of spectroscopic binaries.

7. Other projects

7.1. Orbital systems

A unique multiple system 41+40 Dra has been studied by a combination of spectroscopy and interferometry (Tokovinin et al. 2003). Its extremely high eccentricity e = 0.9754 permits precise timings of periastron passages, giving hope to measure the rate of tidal circularization in the near future.

Poveda & Allen (2004) studied the distribution of major semi-axes of visual binaries of different ages, and found that for all groups studied it is \( \frac{f(a) da}{a} \approx \frac{da}{a} \), up to a maximum value of \( a \) that depends on the age of the binary and on the conditions of the environment it has traversed.
7.2. Trapezium systems

Allen et al. (2004) examined the internal motions of trapezium systems. Combining observations dating back to 1830 with modern ones they found that most systems do not show significant motions. However, a few stars were found escaping from their trapezia with large velocities. These stars were identified as runaway stars recently formed by dynamical interactions.

7.3. Young binaries

On the basis of a broad range of high precision astrometric data (HST, speckle, lunar occultation) Tamazian et al. (2002) have for the first time calculated preliminary orbits and dynamical masses for four binary T Tau stars (V773 Tau, FO Tau, FS Tau and GG Tau Aa) as well as significantly improved that of DF Tau — the only T Tau type star with the known visual orbit prior to this determination. The obtained results allowed to compare empirically determined physical properties of T Tau stars with pre-main sequence stellar evolutionary models. The conclusion was made that the models of Palla & Stahler and Siess, Dufour & Forestini describe somewhat better the observational data.

An improved orbit for T Tau Ba,Bb system allowed Tamazian (2004) to make a first ever direct dynamical estimate for the mass of T Tau Ba which belongs to a rare class of known “infrared companions” (IRC) to T Tau stars. The mass of IRC was found to be 2.3 M⊙, suggesting that it may be a young, heavily reddened F-K star experiencing an episode of enhanced accretion, possibly tied to its orbital phase.

7.4. Binaries with massive components

Discoveries of Wolf-Rayet binary and triple systems have increased markedly in the last few years. With these discoveries has arisen a broader understanding of the properties of the WR stars themselves as well as the interactions of massive stars in binary systems. Two especially noteworthy examples are the discovery of both periodic dust-emitting (Williams et al. 1987) and continuous dust-emitting (Tuthill et al. 1999) WR stars as binary systems with different orbital geometries. The dust arises in the wind-collision zone as a consequence of the high densities and low temperatures in the wind interaction zone at small (∼few AU) binary separations. Many of these are not just binary, however, but multiple systems. HST observations have found extra components for many of these systems (Wallace 2003, Wallace et al. 2001). WR 48, for example, has a 19.1 day orbital period (Hill et al. 2002) with a close companion, as well as a wider companion at a 46 mas separation (Hartkopf et al. 1999, Wallace et al. 2001). While several years ago this would be thought to be an unusual system, we now know of at least 5 such triple systems (WR 48, 98a, 104, 112, 153) where all of the components can be confirmed to interact. At wider separations, HST WFPC2 observations (Wallace 2003, Wallace et al. 2005) suggest that the numbers of visual companions to WR stars are underestimated by a factor of 4-5. Undoubtedly, with the advent of higher angular resolution observations, the number of known close multiple systems will continue to grow. More of these systems are being sought, using K1, IOTA, VLTI, and HST FGS1R interferometric observations to explore binary parameter space inaccessible via either photometry or spectroscopy.

7.5. Disentangling composite spectra

P. Hadrava (Astronomical Institute, Czech Academy of Sciences) has developed new Fourier-based software (KOREL) to disentangle composite spectra. By comparing all available spectra of a system at different orbital phases, the method fits them as a superposition of some a priori unknown spectra attributed to individual components, each one Doppler shifted. The routine can handle differing line strength, and is also able to
decompose telluric lines. Output may include individual radial velocities at each observed epoch or a direct solution of orbital parameters. Moreover, the component spectra, which are obtained simultaneously with the orbital parameters, can be used for subsequent interpretation of the results, e.g., for determination of spectral types.

7.6. Stellar pulsation

Binary and multiple stars with well-characterized components are attractive targets to study a number of different phenomena of high astrophysical interest apart from their own formation and history. This also includes stellar pulsation. Recently, an in-depth study of the triple system DG Leo AB was performed, including photometry, high-resolution spectroscopy and astrometry. The photometric study allowed the detection and precise determination of at least four pulsation frequencies of type Delta Scuti. An additional slow variation due to ellipsoidal variability of the inner binary system Aa,Ab was also reported (Lampens et al. 2005a). Application of Hadra’s spectral disentangling technique allowed to successfully disentangle the component spectra, showing that all three components have similar effective temperatures, surface gravities, ages and masses but different atmospheric chemical compositions as mild metallicity was detected in two of the three A-type stars. However, the Delta Scuti pulsating component has a solar chemical composition (Frémat et al. 2005). Using a newly obtained speckle position, a combined astrometric-spectroscopic orbit based on all astrometric and spectroscopic data known to-date has been derived (Lampens et al. 2005b). Application of the spectral disentangling technique has lately been performed with good result in a number of cases, including also several multiple systems (e.g. Hensberge et al. 2005, Koubsky et al. 2005).

7.7. Eclipsing binaries

Malov (2003) and colleagues have compared radii of eclipsing binary components and single stars and found a noticeable difference for B0V-G0V components of eclipsing binaries and single stars of the corresponding spectral type. This difference can be confirmed by a re-analysis of results of other published investigations and, in particular, it can explain the disagreement between published scales of bolometric corrections.

According to their results, A- and F-type main sequence eclipsing binaries have larger radii and/or higher temperatures than single stars while B-type eclipsing binaries have smaller radii. In proposing explanations for these features they have concluded that the mass-luminosity relation based on empirical data of eclipsing binary components cannot be used to derive the stellar initial mass function. While current knowledge of the empirical mass-luminosity relation for masses more than 1.5$M_\odot$ is based exclusively on eclipsing binaries data, accurate observational data for a few hundred visual binaries of intermediate and high masses should be collected. The initial mass function for this mass range should then be revised.

7.8. Satellite missions

Söderhjelm continued studies on the double star observing capabilities of ESA’s planned Gaia satellite. Although results may not be available until around 2020, one has to be aware of this coming (qualitative and quantitative) leap for double star astronomy. As summarized, e.g., in Söderhjelm (2005), Gaia will observe several hundred thousand eclipsing binaries, millions of astrometric pairs at 1–10 yr period, and tens of millions of longer-period binaries, thus sampling the general period-distribution over almost its full range. With accurate parallax distances for all the systems, we will get by then a much more complete picture of e.g. age- and place-variations of the distributions of orbit sizes and mass ratios, plus of course large numbers of accurate stellar masses.
7.9. Theory of hierarchical star clusters

Surdin (2004) has shown that hierarchical star clusters (H-clusters) containing tens of components may exist in the Galaxy. The number of stars \( N \) in \( \epsilon \) Lyrae-type hierarchical systems is limited by the tidal action of regular gravitational field of the Galaxy and stochastic encounters with giant molecular clouds. In principle, the existence of H-clusters with \( N = 256 \div 512 \) is possible. But in fact, we can expect to find these systems with \( N \leq 16 \) in the recent astrometric surveys. Maximum fractal dimension of the simple stable H-cluster is \( D = 0.3 \div 0.4 \), which is much less than the fractal dimension of molecular clouds \( (D = 2.3 \div 2.5) \). This may be the reason of rare formation of high populated H-systems.

8. Working Group on Binary and Multiple System Nomenclature

Following a Special Session held during the 2003 Sydney General Assembly, a Working Group (B. Mason, chair) was formed within Commission 26. Its purpose is to create the Washington Multiplicity Catalog, a comprehensive database of all known binaries. Data are being compiled from the USNO visual binary catalogs, as well as catalogs of spectroscopic, eclipsing, and interacting systems, plus extra-solar planets and other substellar companions. The goal is to create not only a comprehensive database but also a common nomenclature scheme to describe system hierarchy and to reduce confusion in the study of binaries using multiple techniques.

Statistics on multiplicity and apparent hierarchies of all known field binaries and multiples were recently generated from a draft version of the WMC; these results were presented at the Garching Multiple Stars Workshop in 2005 (Mason & Hartkopf, submitted).

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Commission 29: Stellar Spectra

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John D. Landstreet, Gautier Mathys, Nikolai Piskunov,
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peculiar stars)

1. Introduction

Participants in Commission 29 study various aspects of stellar spectra and the informa-
tion that can be extracted from spectra. The list of fields of interest of the Organizing
Committee members suggest some major current research topics in this area are stellar
chemical compositions and surface/envelope phenomena. Some of the topics of this
commission have overlap with other commissions, such as Commission 14 (Atomic and
Molecular Data), 26 (Double and Multiple Stars), 27 (Variable Stars), 30 (Radial Ve-
locities), 36 (Theory of Stellar Atmospheres), and 37 (Star Clusters and Associations). Many Commission 29 members are also members of these other commissions.

Commission 29 has endorsed several IAU Symposia recently, and our members have been active in organizing and participating in these meetings. In the next section very brief descriptions will be given of these Symposia.

Note that other proposed meetings were favorably considered by the commission, but ultimately were not chosen for IAU Sponsorship. Here is one prominent example. The meeting on Stellar Pulsations and Evolution, with SOC Chairs G. Bono and A. R. Walker, was originally proposed as an IAU Symposium. This commission viewed it favorably but it was not ultimately selected for IAU sponsorship. Happily, the meeting found other funding sources, and took place June 19-24, 2005. Other official IAU Symposia and Colloquia were endorsed by the related commissions noted above.

2. Recent and Approved IAU Meetings Endorsed by Commission 29

Symposium 228, From Lithium to Uranium: Elemental Tracers of Early Cosmic Evolution; May 23-27, 2005, in Paris, France, dedicated to the careers of M. and F. Spite. SOC Chair: R. Cayrel; LOC Chair: V. Hill. Topics included: Lithium in the early Galaxy, extremely metal-poor stars, supernova nucleosynthesis, chemical compositions of globular clusters, observation and theory of neutron-capture element production, abundances in local group and high redshift galaxies.


Symposium 239, Convection in Astrophysics: August 21-25, 2006, in Prague, Czech Republic. SOC Chairs: F. Kupka and I. Roxburgh. Topics will include: observations and modelling of convection and radiative transfer; convection in planets and brown dwarfs; the role of convective mixing in stellar evolution; rotation, oscillations and mass loss; MHD and dynamos.

Christopher Sneden

President of the Commission
Commission 35: Stellar Constitution

PRESIDENT: Wojciech A. Dziembowski
VICE-PRESIDENT: Francesca D’Antona

Abstract. The triennial report from Commission 35 covers its organizational activities and highlights accomplishments in various topics of stellar interior physics.

Keywords. sun: composition, helioseismology, stars: interior, rotation, oscillations, evolution

1. Introduction

The commission home page (http://iau-c35.stsci.edu), which is maintained by Claus Leitherer, contains information on forthcoming and planned conferences supplied by proposers. There are also convenient links to resources that were made available by the owners. The resources contain evolutionary tracks and isochrones from various groups, nuclear reaction, EOS, and opacity data, as well as links to main astronomical journals.

As a routine activity, the Organizing Committee has commented on and ranked proposals for several IAU sponsored meetings. At the forthcoming XXVth IAU General Assembly in Prague there will be two Symposia and three Joint Discussions sponsored by our commission.


There were other meetings in which members of the commission were involved: 3D Stellar Evolution, Livermore (California), July 2002; Nuclei in the Cosmos - VII, Fuji-Yoshida (Japan), July 2002; Cosmic Explosions in Three Dimensions, Austin (USA), June 2003; CNO in the Universe, St Luc (Switzerland), October 2002; Physics and Astrophysics of Neutron Stars, Santa Fe (USA), July 2003; The Future Astronuclear Physics Brussels (Belgium), August 2003; Nuclear Astrophysics XII, Ringberg Castle (Germany), March 2004; Cosmic Abundances as Records of Stellar Evolution and Nucleosynthesis, Austin (USA), June 2004; Supernovae as Cosmological Lighthouses, Padua (Italy), June 2004; 14th European Workshop on White Dwarfs, Kiel (Germany), July 2004; Nuclei in the Cosmos - VIII, Vancouver (Canada), July 2004; Stellar Pulsation and Evolution, Monte Porzio (Italy), June 2005.
The survey of advances in the field of stellar physics which is presented in the subsequent sections of this report was prepared by different members of the the Organizing Committee. Their names are acknowledged in the section headings.

2. High-mass stars (G. Meynet)

The question of the formation and evolution of Pop III stars still remains a very active area of research (see the review by Bromm & Larson 2004). In recent years, abundances at the surface of extremely metal poor halo stars have been measured (see the review by Beers & Christlieb 2005). These observations give insights on the stellar yields of the first massive star generations and pose many intriguing problems: for instance, how to explain the very small scatter of the abundances of many elements at very low Z; why are the peculiar chemical signatures of Pair Instability Supernovae not seen; Can very metal poor massive stars account for the high level of primary nitrogen enrichment required by the observations? Obviously, the answer to all these questions will bring new insights on the early chemical evolution of the galaxies.

The process of formation of massive stars has also received much attention in the past three years. Do massive stars form by merging (Bonnell & Bate 2005) or do they form in the same way as low-mass stars through accretion? Recent observations of disk-like structures centered on a massive protostar (Patel et al. 2005) would favor the latter scenario. From a theoretical point of view, accretion through a disk greatly reduces the radiation pressure experienced by gas in the infalling material. Recently, Krumholz et al. (2005) showed that outflows with properties comparable to those observed around massive stars lead to a significant anisotropy in the radiation field, which also greatly reduces the radiation pressure.

The galaxies of the Local Group offer the opportunity to study massive star evolution at various metallicities, in different environments (see Massey (2003) review). Recently, new spectroscopic and photometric observations of the young super star cluster Westerlund 1 revealed a rich population of Wolf-Rayet stars, OB supergiants and short lived transitional objects (Luminous Blue Variables, extreme B supergiants, yellow supergiants and red supergiants). This cluster is presently the most massive compact young cluster identified in the Local Group, with a mass exceeding that of Galactic Centre clusters. Its mass is consistent with expectations for a Globular Cluster progenitor.

Magnetic fields might also become an important topic in massive star evolution. Detescions of magnetic fields have been reported in a number of hot stars (see the review by Henrichs et al. 2005). Values of a few hundred G up to slightly more than 1 kG have been measured. The question of the origin of these magnetic fields remains an open problem. Recently Mullan & MacDonald (2005) explored the possibility that a dynamo process occurring in radiative layers is responsible for these surface magnetic fields. Stellar evolution models accounting for similar dynamo processes have been computed (Heger et al. 2005; Maeder & Meynet 2005). Such models are able to extract more efficiently the angular momentum from the stellar cores than rotating models without magnetic fields, and a better fit to the observed rotation rates of young pulsars is obtained.

The hypothesis that the progenitors of the long soft gamma ray bursts (GRB) are massive stars has received a new impulse since the non-ambiguous identification of the spectrum of a type Ic SN in the afterglow of the GRB030329 (Mazzali et al. (2003)). According to the collapsar scenario (Woosley 1993), at least three conditions should be fulfilled by the progenitor for giving birth to a GRB: (i) to form a BH, (ii) to retain sufficient angular momentum in the central regions for allowing the formation of an accretion disk, (iii) to lose the H-rich envelope. The necessity to lose mass and, at the
same time, to retain sufficient angular momentum are not conditions easy to meet. On the other hand, GRB are very rare events requiring some special circumstances to occur. Others explored the possibility that their progenitors followed an homogeneous evolution due to very fast rotation (Yoon & Langer 2005; Woosley & Heger 2005).

This small section does not allow us to cover many other interesting questions relevant to massive star evolution which were discussed in the literature during the last three years. For more information on massive star evolution, the interested reader may consult the web page of the IAU working group on massive stars (http://www.astroscu.unam.mx/mas-sive.stars/). Much very useful information, regularly updated, can be found there as links to the Massive Star Newsletter, to conference web pages, and to databases.

3. Low-Mass Stars (D. VandenBerg)

In the area of low-mass stars, recent results pertaining to diffusive and rotating stellar models deserve to be highlighted, along with efforts to understand the first stars that formed after the Big Bang. The primordial Li abundance implied by the concordance of WMAP and Big-Bang nucleosynthesis results initially appeared to be problematic because it was a factor of 2–3 larger than the Li abundances measured in the oldest Population II stars. However, Richard et al. (2005) have shown that their models, which allow for gravitational settling and radiative accelerations in the presence of weak turbulence, can explain much of this difference — suggesting that an improved understanding of turbulent transport in the radiative zones of stars may be all that is needed to completely explain the discrepancy. Diffusive models are also able to reproduce the turnover morphology of the old open cluster M67 without the need for any convective core overshooting at all (see Michaud et al. (2004)), and it seems likely that the “Li dip” observed among Hyades main-sequence stars can be explained in terms of the competition between gravitational settling and the circulation currents generated in slowly rotating stars (see Théado & Vauclair (2003)). In addition, the coupling between circulation currents and magnetic fields could well explain why the Sun has close to solid-body rotation between \( \sim 0.2 \) and \( 0.7R_\odot \) (Eggenberger et al. (2005)). Another notable achievement is the fact that tracks for \( \approx 0.8–2M_\odot \) stars have now been extended to the tip of the giant branch (Chame et al. (2005)), mainly for the purpose of addressing the observed chemical abundance anomalies in giants (see the section on mixing in stars, below). The discovery of HE 0107-5240 (Christlieb et al. (2002)), which has \([\text{Fe}/\text{H}] < -5\) and very large CNO abundances, lead Weiss et al. (2004) and Picardi et al. (2004) to examine whether large \([\text{CNO}/\text{Fe}]\) ratios could be produced in initially metal-free stars as a result of the peculiar He core flash that occurs in Pop. III stars, or whether they are actually second-generation objects that formed out of a mixture of primordial material and ejecta from a single primordial supernova. Both investigations conclude that the first possibility does not seem to be viable, and thus suggest that the second alternative is the most promising one to explore further. Curiously, the observed \(^{13}\text{C}/^{12}\text{C}\) ratio in HE 0107-5240 presents difficulties for both scenarios. Motivated by the fact that stars with planets appear to be more metal rich than the average field star, Cody & Sasselov (2005) studied the general effects of planet consumption (also see Dotter & Chaboyer (2003)), but were unable to find any clear correlations of the properties of their models with those of stars known to possess planets. Nevertheless, the pollution of stars by the ingestion of planets (or by the the ejecta from supernova or asymptotic giant branch stars, see below) must certainly occur. We note, finally, that the latest large grids of tracks and isochrones for application to studies of stellar populations are those by Pietrinferni et al. (2004).
4. AGB Stars (F. D’Antona)

We refer to the review by Herwig (2005) for detailed and complete references to most of the theoretical research of the years 2002–2005 on AGB evolution. The problem of the third dredge-up and its consequences for the formation of Carbon stars and for the associated s-process nucleosynthesis is still treated in a parametric way, but many hints are now quantified about the dependence of its efficiency (defined by the parameter $\lambda$) on the input physics, such as efficiency of convection, mass loss and, notably, even on the nuclear reaction rates (Herwig 2004). Study of s-process production has been mainly concentrated on the role and extension of the $^{13}$C pocket in low mass AGBs (e.g. Lugano et al. 2003 or Siess et al. 2004). The work of Nollett et al. (2003) concentrates on the effect of the non standard mixing process called “cool bottom processing” (CBP) on important isotopic ratios such as $^{16}$O/$^{18}$O, $^{17}$O/$^{18}$O, $^{15}$N/$^{14}$N, $^{26}$Al/$^{27}$Al, C/O, and N/O during the AGB phase of a 1.5$M_\odot$ star. Attention has been devoted to the study of the fast evolutionary phases of post-AGBs (Hajduk et al. 2005) and interpretation of the detailed chemistry of the hot PG 1159 objects (e.g. Lugano et al. 2003).

There has been considerable interest in the most massive AGB stars. These stars evolve in the early life of globular clusters (GCs) and eject their envelopes processed by Hot Bottom Burning (HBB). This matter gives to second generation stars in the clusters, producing pattern of abundances known as chemical anomalies among GC stars (D’Antona & Da Costa (2004)). Some GC data, such as the lithium abundances in these stars (Gratton et al. (2004)) and the peculiar morphologies of some horizontal branches (D’Antona & Caloi (2004)), strongly favour this scenario, but the modeling of some chemical anomalies (e.g. the O–Na and Mg–Al anticorrelations, the constancy of the global CNO abundances) are not in agreement with the GC data, casting doubts about the reliability of the self–enrichment models (Fenmer et al. (2004), Herwig (2004)).

On the contrary, some researchers are convinced that the AGB modeling is not adequate and the scenario of self–enrichment is correct. Ventura & D’Antona (2005) have recently shown that the yields of HBB nucleosynthesis are very poorly constrained, as they change by orders of magnitude by changing the efficiency of convection in the AGB — and, indirectly, the efficiency of mass loss. The self–enrichment scenario requires that the HBB phase is modelled by a very efficient convection model, such as the Full Spectrum Turbulence model of Canuto, Goldman, & Mazzitelli (1996).

5. Supernovae (E. Müller)

The precise scenario of SNe Ia which are commonly attributed to thermonuclear explosions of Chandrasekhar-mass C+O white dwarfs in a binary system is still controversial although substantial progress has been achieved during the past three years (e.g. Hillebrandt (2004)), particularly through the development of 3D models of thermonuclear supernova explosions (Reinecke (2002), Gamezo et al. (2003), Travaglio et al. (2004), Röpke & Hillebrandt (2004), Gamezo et al. (2005), Röpke (2005), Röpke & Hillebrandt (2005a), Röpke & Hillebrandt (2005b)). The most advanced of these models (Röpke & Hillebrandt (2005b)) has considerable predictive power and allows one to study observable properties of SNe Ia, such as their light curves and spectra, without adjustable non-physical parameters, and allows for firm predictions of the nucleosynthesis yields (Travaglio et al. (2004)) from the explosions. The new 3D models have stimulated a quest for better data, covering the spectroscopic and photometric evolution in all wave bands from very early epochs all the way into the nebular phase. Such results have been obtained by the Euro-
pean Supernova Collaboration (ESC; http://www.mpa-garching.mpg.de/~rtn) for a sample of nearby SNe Ia.

Progress in modeling core collapse supernovae was achieved by 2D radiation-hydrodynamic simulations with multi-frequency, multi-angle Boltzmann neutrino transport taking into account also the effects of rotation (Buras et al. 2004, Janka et al. (2005a), Janka et al. (2005b)). Even these up-to-now most sophisticated simulations fail to produce powerful explosions. However, they are very close to success, as some models showing weak explosions (Janka et al. (2005a)). The success of previous and recent 2D and 3D simulations with grey (e.g. Fryer & Warren (2004)) or multi-group (e.g. Walder et al. (2005)) flux-limited neutrino diffusion is therefore not confirmed. Whether these results suggest missing physics, possibly with respect to the nuclear equation of state and weak interactions in the subnuclear regime, or whether they indicate a fundamental problem with the neutrino-driven explosion mechanism requires further investigations (e.g. Buras et al. 2004, Janka et al. (2005b), Mezzacappa (2005)). It is now, however, generally agreed that 1D models with accurate neutrino transport and standard microphysics input fail to explode by the delayed, neutrino-driven mechanism for progenitors with $M > 10M_\odot$ (e.g. Liebendörfer et al. (2005)). Both 2D and 3D simulations of neutrino-driven convection show that hydrodynamic instabilities can lead to low-mode ($l = 1, 2$) flow asymmetries in the neutrino-heated layer behind the supernova shock wave (e.g. Blondin et al. (2003), Janka et al. (2005a)). This suggests a natural explanation for global asymmetries of observed core collapse supernovae and for observed pulsar recoil velocities (Scheck et al. 2004). Studies partially employing simpler microphysics and neutrino transport, or even no transport at all, focused on the effects of rotation (e.g. Fryer & Warren (2004), Ott et al. (2005)), magnetic fields (e.g. Akiyama et al. (2003), Yamada & Sawai (2004)) and on the gravitational radiation produced by core collapse supernovae (Müller et al. (2004), Ott et al. (2004)).

Another active area of research has been the investigation of the connection between supernovae/hypernovae and (long?) gamma-ray bursts driven by observations of SNe Ib/c coincident in space and time with observed GRBs (e.g. Hjorth et al. (2003), Mazzali et al. (2003)).

6. Transport processes in stars (C. Charbonnel)

Although the standard stellar models have been able to reproduce many observed features, it becomes clear now that non-standard transport processes of the chemicals and of angular momentum have to be included in the modern models in order to reproduce detailed data in several parts of the HR diagram. Rotation appears to be a key ingredient, together with internal gravity waves and magnetic fields.

New theoretical results by Mathis & Zahn (2004) have improved modeling of the rotational mixing which occurs in stellar radiation zones, through the combined action of thermally-driven meridional circulation and of turbulence generated by the shear of differential rotation. This will allow a simultaneous treatment of the hydrodynamical processes in the bulk of radiative zones and in the tachoclines.

Another delicate aspect concerns the treatment of turbulence in stars. Mathis et al. (2004) have reviewed various prescriptions which have been proposed for the turbulent transport of matter and angular momentum in differentially rotating stellar radiation zones. They present a new prescription for the horizontal transport associated with the anisotropic shear turbulence which is produced by the differential rotation in latitude; this "\(\beta\)-viscosity" is drawn from torque measurements in the classical Couette-Taylor experiment.
Regarding main sequence stars, it was known for a long time that the classical hydrodynamical processes related to rotation, i.e., meridional circulation and shear turbulence, are insufficient to explain the internal rotation profile of the Sun as given by helioseismology. The incorporation of the internal gravity waves in hydrodynamical rotating models has helped solving this problem, and the corresponding models now explain both the solar rotation and the lithium abundance in main sequence stars over a large mass range (Talon & Charbonnel 2003; Charbonnel & Talon 2005).

Young et al. (2003) present an analysis of the response of a radiative region to waves generated by a convective region of the star; this wave treatment of the classical problem of “overshooting” gives extra mixing relative to the treatment traditionally used in stellar evolutionary codes. The interface between convectively stable and unstable regions is dynamic and nonspherical, so that the nonturbulent material is driven into motion, even in the absence of “penetrative overshoot”. These motions may be described by the theory of nonspherical stellar pulsations and are related to motion measured by helioseismology. Multidimensional numerical simulations of convective flow show puzzling features, which are explained by this simplified physical model. Gravity waves generated at the interface are dissipated, resulting in slow circulation and mixing seen outside the formal convection zone. The approach may be extended to deal with rotation and composition gradients (“seminconvection”).

Regarding internal gravity waves, many issues remain open: The excitation of the waves by the stellar convective zones (cores and envelopes), the effect of the Coriolis force, the interaction with magnetic fields, and the direct transport of chemicals. Progress should come from 2 or 3D simulations. For example, the excitation of internal gravity waves by penetrative convective plumes has been investigated using 2-D direct simulations of compressible convection by Dintrans et al. (2005). The wave generation is quantitatively studied from the linear response of the radiative zone to the plume penetration, using projections onto the g-mode solutions of the associated linear eigenvalue problem for the perturbations. This allows an accurate determination of both the spectrum and amplitudes of the stochastically excited modes.

Much effort has been done on the theoretical side for the treatment of rotation coupled to magnetic fields. In addition to the classical rotational mixing, which results from the combined action of the thermally-driven meridional circulation and of the turbulence generated by the shear of differential rotation, Mathis & Zahn (2005) have included the effect of an axisymmetric magnetic field in a self-consistent way. They treat the advection of the field by the meridional circulation, its Ohmic diffusion, and the production of its toroidal component through the shear of differential rotation. The Lorentz force is assumed not to exceed the centrifugal force; it acts on the baroclinic balance and therefore on the meridional flow, and it has a strong impact on the transport of angular momentum.

Many works regarding the impact of the processes described above have been done and published for stars on the main sequence. However the advanced stellar phases present many interesting and complementary constraints. From the observational point of view, many abundance anomalies both on the RGB and AGB point towards non standard transport processes. The role of rotationally induced mixing in the development of abundance anomalies in giants is difficult to assess and the current rotating RGB models make some very contradictory predictions (Denissenkov & Vandenberg 2003; Chamat et al. 2005; Palacios et al. 2005). However a general result is that after the completion of the first dredge-up, the degree of mixing is maximized in the case of a differentially rotating envelope, as anticipated in previous studies.
7. Helio- and astero-seismology (W. Dziembowski)

The significance of helioseismic models for whole astrophysics was again demonstrated in the wake of the downward revision by 25-35% of the photospheric C, N, and O element abundances in the Sun (Asplund et al. 2004). When these new abundance data were taken as representative for the overall heavy element abundance in solar modeling, a conflict with helioseismic models became apparent. Bahcall et al. (2005) showed that the conflict could be resolved by an ad hoc 11% increase in opacity in the outer part of radiative interior. Subsequent solutions included significantly above standard Ne abundance (Antia & Basu 2005) as well as nonstandard element diffusion and accretion processes in the sun’s evolution (Guzik et al. 2005). Drake & Testa (2005), who recently measured the Ne abundance in a sample of nearby solar-like stars from their X-ray spectra, found that the standard abundance has been underestimated on average by about a factor of 2.5. This result seems to confirm the solution proposed by Antia & Basu (2005).

Models constrained by frequency data (seismic models) were obtained for stars belonging to various types of multimode pulsators. The greatest interest was in modeling solar-like pulsators such as $\alpha$ Cen (Thoul et al. 2003), $\eta$ Boo (Di Mauro et al. 2004; Carrier et al. 2005), $\alpha$ CMi (Kervella et al. 2004; Eggenberger et al. 2005), and $\mu$ Arae (Bazot et al. 2005). The last object is an exoplanets host star and the primary goal was determination of its internal metallicity. Still there are mostly only premises for seismic constraints from solar-like oscillation data.

Seismic models were also calculated for two multimode $\beta$ Cephei stars: HD129929 (Dupret et al. 2004) and $\nu$ Eri (Pamyatnykh et al. 2004; Ausseloos et al. 2004). The models gave strong constraints on the convective overshooting from the core and evidences for inward rising rate of rotation. Charpinet et al. (2005) calculated a seismic model of the sdB pulsator PG 1219+534 yielding precise total mass and mass of the hydrogen envelope which determines evolutionary status of the object. Possible seismic evidence for rapidly rotating cores of sdB stars was considered by Kawaler & Hostler (2005).


Testing various aspects of white dwarfs with oscillation data was the subject of several papers. In particular, Metcalfe et al. (2004) constructed a seismic model of the massive white dwarf BPM 37093 finding the mass of its crystallized core in agreement with theoretical expectations. Prospects of accurate testing of diffusion theory and on neutrino cooling rates were considered by Metcalfe et al. (2005) and Winget et al. (2004), respectively.

Oscillation frequencies were not the only seismic observables that have been used to constrain stellar interior physics. Amplitudes and mode life times measured for $\alpha$ Cen were compared with predictions based on stochastic excitation theory (Bedding et al. (2004); Samadi et al. (2004)). Significant discrepancies with current models were found. Application of photometric and spectroscopic data on mode amplitudes and phases in $\delta$ Scuti oscillation spectra for testing models of the outer convective zone in A and F-type stars was proposed by Daszyńska-Daszkiewicz et al. (2003) and by Moya et al. (2004).

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Wojciech A. Dziembowski

President of the Commission
Commission 36:
Theory of Stellar Atmospheres

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VICE-PRESIDENT: John Landstreet
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S. Balachandran, D. Dravins, P. Hauschildt, D. Kiselman,
K. N. Nagendra, C. Sneden, G. Tautvaišienė, K. Werner

1. Introduction
Commission 36 covers all the physics of stellar atmospheres. The scientific activity in
this large field has been very intense during the last triennium and led to the publication
of a large number of papers which makes an exhaustive report practically unfeasible. As
a consequence we decided to keep the format of the preceding report: first a list of areas
of current research, then web links for obtaining further information.

Many conferences and workshops were held during this report period on topics within
the scope of commission 36. Some of them were sponsored by IAU: “Young Neutron
Stars and their Environment” (IAU Symp 218), “Stars as Suns: Activity, Evolution and
A Crossroads of Astrophysics” (IAU Symp 227), “From Lithium to Uranium: Elemental
Tracers of Early Cosmic Evolution” (IAU Symp 228), “The Environment and Evolution
of Binary Stars” (IAU Coll 191), and “Variable Stars in the Local Group” (IAU Coll
193).

2. Primary research areas 2002-2005

2.1. Physical processes

**General properties** Improved models available to the community. Grids of synthetic
fluxes and spectra. Calibrating parameterized models through physical modeling. Cali-
brating abundance determinations by filter photometry or low-resolution spectroscopy.

**Stationary processes within stellar atmospheres** Convection (granulation) in
surface layers, and its effects upon emergent spectra. Interplay between convection and
non-radial pulsation. Scales of surface convection in stars in different stages of evolution.
Hydrodynamic simulations of entire stellar volumes.

**Transient processes** Shocks in pulsating stars. Radiative cooling of shocked gas.
Emission lines as shock-wave diagnostics. Particle acceleration during flares. Interaction
of jets with interstellar medium. Episodic outflows and star-disk interaction.

**Magnetic phenomena** Magnetic structures in single and binary stars. Dynamo gen-
eration of magnetic fields by convection. Effects by magnetic fields on convective struc-
tures. Magnetic cycles at varying activity levels. Polarized radiation, gyrosynchrotron
and X-ray emission. Interpreting Zeeman-Doppler images of stellar surfaces. Hanle effect
diagnostics in stellar environments.


**Forbidden lines and maser emission** Molecules in atmospheres of cool giant stars. Effects of fluorescence. Permitted and forbidden lines from shocked atmospheres of pulsating giants. Maser and laser emission from stellar envelopes.


**Molecules** Chromospheric structures and temperature inhomogeneities. Cool molecular constituents in warm stars. Molecular spheres around red giants. Molecular opacities, and non-LTE effects. Role of molecular hydrogen.

### 2.2. Stellar structure

**Structures across stellar disks** Doppler mapping of starspots. Radii and oblateness at different wavelengths for giant stars. Gravitational microlensing to test model atmospheres. Interaction between rotation and pulsation. Doppler tomography of stellar envelopes.

**Stellar coronae** Coronal heating mechanisms (quiescent and flaring). Effects of age and chemical abundance. Multicomponent structure. Coronal in also low-mass stars and brown dwarfs. Diagnostics through X-ray spectroscopy and radio emission.


**Dust, grains, and shells** Formation of stellar dust shells. Grains in the atmospheres of red giants, and in T Tauri stars.

### 2.3. Different classes of objects

**Pulsating stars and asteroseismology** Classically variable stars, and 'ordinary' solar-type ones. Inverting observed pressure-mode frequencies into atmospheric structure. Mass-loss mechanisms in pulsating stars. Effects of rapid rotation on pulsation.

**Binary stars** Atmospheric structure and magnetic dynamos in common-envelope binaries. Role of binarity on mass loss. Tidal effects. Non-LTE effects by illumination
from the component. Reflection effects in close binaries. Colliding stellar winds.


**Special objects**  Central stars of planetary nebulae. Population III stars of extremely low metallicity. Protostars. Accretion disks and coronal activity in young stars.

**Interaction with exoplanets**  Effects of planets on the atmospheres of evolved red giants. Characteristics of stars hosting exoplanets.

### 2.4. Development of techniques

**Computational techniques**  Parallel (super)computing to simulate convective surface regions, and throughout complete stars. Neural networks and machine-learning algorithms. Preparing for the widely distributed network of computational tools and shared databases being developed for the forthcoming computing infrastructure GRID.

### 2.5. Applications of stellar atmospheres

Besides their study per se, stars are being used as probes for other astrophysical problems:

**Exoplanets**  Variable wavelength shifts in stellar spectra serve as diagnostics for radial velocity variations induced by orbiting exoplanets. Atmospheric modeling can indicate which spectral features are suitable as such probes, and which should be avoided due to their sensitivity to intrinsic stellar activity.

**Chemical evolution in the Galaxy**  How accurately observations of stellar spectral features can be transformed into actual chemical abundances depends sensitively on the sophistication of the stellar model atmospheres.

**Kinematics of the Galaxy**  Planned space missions intend to measure radial velocities for huge numbers of stars. Model atmospheres are used to identify suitable spectral features for such measurements in different classes of stars.

**Galaxies and cosmology**  Stars are the main observable component of galaxies, and population synthesis for galaxies utilize model atmospheres to interpret observations. Cosmological origin of the lowest-metallicity stars.
3. Web links for further information

The following collection of links provides introductions and overviews of several significant subfields of the physics of stellar atmospheres.

3.1. Calculating atmospheric models and spectra

ATLAS, SYNTHE, and other model grids
http://kurucz.harvard.edu
MARCS, model grids
http://www.marcas.astro.uu.se
Tuebingen: Stellar atmospheres – grid of models
http://astro.uni-tuebingen.de/groups/stellar
http://astro.uni-tuebingen.de/~rauch/
CCP7 – Collaborative Computational Project
http://ccp7.dur.ac.uk
CLOUDY – photoionization simulations
http://www.nublado.org/
MULTI – non-LTE radiative transfer
http://www.astro.uio.no/~matsc/mul22/mul22.html
PANDORA – atmospheric models and spectra
http://cfa-www.harvard.edu/~rloeser/pandora.html
PHOENIX – stellar and planetary atmosphere code
http://www.hs.uni-hamburg.de/EN/For/ThA/phoenix/index.html
STARLINK – theory and modeling resources
http://www.astro.gla.ac.uk/users/norman/star/sc13/sc13.htx
Synthetic spectra overview
http://www.am.ub.es/~carrasco/models/synthetic.html
TLUSTY – model atmospheres
http://tlusty.gsfc.nasa.gov

3.2. Useful links from Research groups or Individual researchers

Vienna: Stellar atmospheres and pulsating stars

Potsdam: Stellar convection
http://www.aip.de/groups/sternphysik/stp/convect_neu.html
M. Asplund: Stellar convection and line formation
http://www.mso.anu.edu.au/~martin
R. F. Stein: Convection simulations & radiation hydrodynamics
http://www.pa.msu.edu/~steinr/research.html#research
D. Dravins: Stellar surface structure
http://www.astro.lu.se/~dainis/HTML/GRANUL.html

A. Collier Cameron: Starspots and magnetic fields on cool stars
D. F. Gray: Stellar rotation, magnetic cycles, velocity fields
http://www.astro.uwo.ca/~dfgray/
J. F. Donati: Magnetic fields of non degenerate stars
http://webast.ast.obs-mip.fr/people/donati/field.html
M.Jardine: Stellar coronal structure
http://star-www.st-and.ac.uk/~mmj/Welcome_research.html

Munich: Programs, Models, Fluxes and synthetic Spectra of the atmospheres of hot stars
http://www.usm.uni-muenchen.de/people/adi/adi.html

S.Jeffery: Stellar model grids, hot stars
http://star.arm.ac.uk/~caj/

P.Stee: Be-star atmospheres and circumstellar envelopes
http://www.obs-nice.fr/stee/Bemodel.html
http://www.obs-nice.fr/stee/simugb.html

J.L.Linsky: Cool stars, stellar chromospheres and coronae
http://jilaww.colorado.edu/~jlinsky/

G.Basri: Brown dwarfs
http://astro.berkeley.edu/~basri/bdwarfs/

Adam Burrows: M dwarfs, brown dwarfs etc model atmospheres
http://zenith.as.arizona.edu/~burrows/

Vienna: Atomic Line Database (VALD)
http://sms.astro.univie.ac.at/vald/

D.Montes et al.: Libraries of stellar spectra
http://www.ucm.es/info/Astrof/spectra.html

R.J.Rutten: Lecture notes: Radiative transfer in stellar atmospheres
http://www.fys.ruu.nl/~rutten/node20.html

Monique Spite
President of the Commission
Commission 45: Stellar Classification
Classification Stellaire

PRESIDENT: Christopher Corbally
VICE-PRESIDENT: Sunetra Giridhar
ORGANIZING COMMITTEE: Coryn Bailer-Jones,
Roberta Humphreys, Davy Kirkpatrick, Tom Lloyd Evans,
Xavier Luri, Dante Minniti, Laura Pasinetti,
Vytautas Stražys, & Werner Weiss

1. Introduction

This report, like its predecessors, focuses on areas which have been especially active since the last General Assembly. Two major developments have been the unification of the T-dwarf standards and the new general catalogue of stellar spectral classifications.

2. Working Groups

The following Working Group publishes a biannual newsletter, which may be accessed along with information on its activities from a link on the Web page of Commission 45: http://www.iap.fr/com45uai/
   Working Group on Standard Stars
   chairperson: Chris Corbally
   editor of the Newsletter: Richard Gray

Other Working Groups that are related to Division IV and have a specific concern to Commission 45 are also listed at the above Web page.

3. Classification of Ultra-Cool Dwarfs

(Sandy K. Leggett)

There has been a major step forward in L and T dwarf spectral classification in the last three years. The two different schemes of Burgasser et al. (2002) and Geballe et al. (2002) for IR typing of T dwarfs have now been “unified”. The title of the ApJ paper is “A Unified Near Infrared Spectral Classification Scheme for T Dwarfs” by Burgasser, Geballe, Leggett, Kirkpatrick, and Golimowski (2005). As the IR is the only sensible wavelength for typing T dwarfs one can imagine this will be the canonical paper on T dwarf classification, at least for a while. The next steps will be understanding metallicity and gravity effects.

REFERENCES
Burgasser et al., 2002ApJ...564..421B
Burgasser et al., 2005astro.ph.10090B
Geballe et al., 2002ApJ...564..466G
4. Classification of Extrasolar Planet Stars

(Dante Minniti, Chris Corbally)

More than 150 extrasolar giant planets have been discovered to date (Schneider 2005). But how big, how massive, how dense are they? In other words, how similar to the giant planets of the Solar System are these extrasolar planets? This is difficult to answer until the properties of their parent stars are known. In fact, the uncertainty in the stellar parameters is the most critical limitation to know the properties of these planets. For example, a difference of 1 spectral subclass implies a change of 10% in M*, and 10% in R* for solar type stars. These errors are propagated to the planetary parameters, making for example the mean planetary density change by 30% all other things being equal.

In this topic we have to make a clear distinction between the nearby stars and the distant stars. The radial velocity searches measure $M_p \sin i$, and are targeted to nearby stars that have known parallaxes, and zero reddening (e.g., Fischer et al. 2005).

Gray et al. (2003) are completing a project, under the aegis of the Nearby Stars (NStars) /Space Interferometry Mission Preparatory Science Program, to obtain medium resolution spectra, spectral types, and, where feasible, basic physical parameters for the 3600 dwarf and giant stars earlier than M0 within 40 pc of the Sun. They give precise, homogeneous spectral types first as a description of the parent star and then as an essential help towards the starting parameters for comparison with synthetic spectra, derived from Kurucz atmospheric models without overshoot. The comparison is refined using a SIMPLEX method. Output are the effective temperature, surface gravity, and overall metallicity [M/H], and also measures of the chromospheric activity of the program stars. Accuracy and precision are extensively discussed, and it is found that the parameters from this study compare very well with the best in the literature derived from detailed spectral analysis.

In contrast, the transit searches measure $R_P$, and are pointed towards more distant stars, with uncertain distances and redenings. The full characterisation of the companions (M-type stars, brown dwarfs or exoplanets) requires high-resolution spectroscopy to measure properly masses and radii. With the advent of massive variability surveys over wide fields (e.g., Udalski et al. 2004), the large number of possible candidates makes such a full characterisation for all of them impractical. Future transit searches from space are expected to discover large numbers of extrasolar planet candidates (e.g., the CoRoT and Kepler missions, Broo et al. 2003, Borucki et al. 2004).

Gallardo et al. (2006) have developed a fast technique to pre-select the most promising candidates using either near-IR photometry or low resolution spectroscopy. This method is based on the well-calibrated surface brightness relation along with the correlation between mass and luminosity for main sequence stars, so that not only can giant stars be excluded but also accurate effective temperatures and radii measured. The main source of uncertainty arises from the unknown dispersion of extinction at a given distance. They applied this technique to observations of a sample of 34 stars extracted from the low-depth transits identified by OGLE during their survey in the Carina fields of the Galactic disc. They infer that at least 78% of the companions of the stars which are well characterised in this sample are not exoplanets.

Eight transiting extrasolar planets are known to date: HD209458-b (Charbonneau et al. 2000), OGLE-TR-56-b (Konacki et al. 2003), OGLE-TR-132-b (Bouchy et al. 2004), OGLE-TR-111-b (Pont et al. 2004), OGLE-TR113-b (Bouchy et al. 2004, Konacki et al. 2004), and OGLE-TR-10-b (Konacki et al. 2005), TrES-1-b (Alonso et al. 2004), and HD 149026-b (Sato et al. 2005). The parent stars of these new planets have been accurately measured by these authors, and knowledge of their densities has allowed to develop and
test models of planetary formation and evolution.

REFERENCES
Alonso et al., 2004ApJ...613L.153A
Brode et al., 2003A&A...405.1137B
Borucki F., et al., 2004A&A...421L..13B
Bouchy et al., 2004A&A...421L..13B
Charbonneau et al., 2000ApJ...529L..45C
Gallardo et al., 2005A&A...431..707G
Gray et al., 2003AJ....126.2048G
Fischer et al., 2005ApJ...620..481F
Konacki et al., 2003Natur.421..507K
Konacki et al., 2004ApJ...609L..37K
Konacki et al., 2005ApJ...624..372K
Pont et al., 2004A&A...426L..15P
Sato et al., 2005astro.ph..07009S
Udalski et al., 2004AcA....54..313U

5. Catalogues & Atlases

5.1. General Catalogue of Stellar Spectral Classifications

A new and exciting compilation of spectral classifications is in process by Brian A. Skiff of Lowell Observatory. This general catalog contains spectral classifications for stars collected from the literature and serves as a continuation of the compilations produced by the Jaschek's, by Kennedy, and by Buscombe. Its superior value lies in giving citations for every entry, in listing only types derived from spectra (viz. line and band strengths or ratios), in including full types with remarks, and in being as complete as possible. This completeness extends to the large objective-prism surveys done at Case, Crimea, Stockholm/Uppsala, Abastumani, and elsewhere. The classifications include MK types as well as types not strictly on the MK system (white dwarfs, Wolf-Rayet, etc.), and in addition simple HD-style temperature types. System-defining primary MK standard stars are included from the last lists by Morgan and Keenan, while Garrison's (1994mpyp.conf....3G) list of MK 'anchor points' is being noted in this regard.

As a 'living catalogue', an attempt is being made to keep up with current literature, and to extend the indexing of citations back in time. The compilation is being made available through the CDS, and access can be gained via its descriptive page at http://cdsweb.u-strasbg.fr/viz-bin/Cat?III/233

5.2. Galactic O-Star Catalogue

Walborn reports a catalog of 378 Galactic O stars, with accurate spectral classifications, that is complete for $V<8$ but includes many fainter stars.
2004ApJS...151..103M Maíz-Apellániz et al.

5.3. Far-UV Spectral Atlases

Walborn also reports the following atlases of far-ultraviolet spectra secured with the FUSE satellite:
2002ApJS..141..443W Walborn et al., far-uv atlas of MC OB stars
6. Spectral Classification

(Brian A. Skiff)

Approximately 20,000 new spectral classifications were published during the triennium. This includes types determined from spectra at wavelengths from the near-UV to the near-IR through the traditional MK process, as well as detailed fitting of line-profiles to model atmospheres, but not from fits to coarse spectral energy distributions, photometric colors, or types inferred from direct determinations of temperature and gravity. The summary below describes material published in mainstream journals between cover dates July 2002 and June 2005. Papers with “many” stars are highlighted in preference to those with only a few.

Though spectral classification of low-mass stars is the current “growth industry”, the more general emphasis has been on all four corners of the Hertzsprung-Russell diagram: of extremes in mass, age, temperature, and luminosity. Thus the less common surveys of ordinary stars are a welcome respite.

6.1. Young low-mass stars and substellar objects

With the more complete establishment of classification criteria for low-mass stars and substellar bodies in the far-red and near-infrared, comprehensive searches for these objects in star-forming regions have become a bandwagon topic. In many cases the recent near-IR catalogues (2MASS at JHK and DENIS at IJK) have been used to sort out likely candidates from field stars. The recent catalogues from the ROSAT and Chandra X-ray spacecraft have also been examined for visible or near-IR stellar counterparts. In the first list of citations below, very faint stars in Chamaeleon have been canvassed by groups led by Gómez, Comeron, Luhman, and Lyo.

2002A&A...398..494G Gómez & Persi, near-IR spectra in Cha I
2003AJ....125.2134G Gómez & Mardones, near-IR spectra in Cha I
2004A&A...417..583C Comeron et al., more stars in Cha I
2004ApJ...602..816L Luhman, census of Cha I
2004ApJ...616.1033L Luhman et al., epsilon Cha
2004MNRAS.355..363L Lyo et al., PMS stars in eta Cha

Other (partly-related) southern star-forming regions have also been searched specifically for low-mass stars:

2005AJ....129.1564K Kim et al., low-mass stars in CG 30/31/38
2002ApJ...575..484G Gizis, brown dwarfs in TW Hya assoc
2002AJ....124.1670M Mamajek et al., post-T Tau stars Cen/Cru
2003A&A...406.1001C Comeron et al., Lupus 3 dark cloud
2002AJ....124..404P Preibisch et al., Upper Sco OB assoc
2004AJ....127..449M Martin et al., brown dwarfs in Upper Sco from DENIS

The traditional Taurus-Auriga region, including the less well observed westward extension into Aries, has not been ignored either. The Hartigan & Kenyon paper cited below made use of the STIS spectrograph on HST to obtain separate spectra of the components of subarcsecond binaries among many well-known T Tauri stars.

2002AJ....124.2164A Andersson et al., survey of Lynds 1457 (Aries)
2003ApJ...583..334H Hartigan & Kenyon, subarcsec binaries in Taurus-Auriga
More distant, obscured star-forming regions in Perseus and Cepheus have also been searched for low-mass stars and more ordinary pre-main-sequence objects:

2003ApJ...593.1093L Luhman et al., census of IC 348
2005ApJ...618..810L Luhman et al., more stars in IC 348
2003AJ....125.1480A Aspin, NGC 1333 S
2004AJ....127.1131W Wilking et al., NGC 1333
2004AJ....128.1233H Herbig et al., NGC 1579
2004AJ....128.8055S Sicilia-Aguilar et al., low-mass stars near Cep OB2

The inventories of low-mass stars and substellar objects in Orion has been extended both in the Trapezium region and in areas outside the much-observed Orion Sword, extending as far north as lambda Orionis, inspired by recent deep photometric surveys (viz. Dolan & Mathieu 2002AJ....123..387D).

2003A&A...404..171B Barado y Navascues et al., sigma Ori substellar population
2004A&A...416..677A Alcalá et al., stars in Lynds 1616 (Orion)
2004ApJ...610.1048S Slesnick et al., low-mass stars in Orion nebula cluster
2004ApJ...610.1064B Barado y Navascues et al., lambda Ori
2005AJ....129..907B Briceño et al., low-mass variables in Ori OB1

6.2. Older low-mass nearby stars in the field

Similar work amongst the nearest stars on the faint end of the 'high-gravity' main-sequence has been facilitated by 2MASS and DENIS as well as comprehensive proper-motion and photometric catalogues (SDSS, revisions of the Luyten catalogues, etc). "Tee-garden’s Star" was added to the short list of named stars having the very largest proper motions. The large set of uniform spectral data by Cushing et al. should greatly aid the assessment of spectral variations with temperature, gravity, age, and metallicity down to the lowest-mass objects observed so far.

2003AJ....125.1598L Lepine et al., new northern large-motion stars
2003AJ....126..353R Rojo & Ruiz, Calan-ESO proper-motion stars
2003AJ....126.2421C Cruz et al., "Meeting the cool neighbors. V", M & L dwarfs
2003AJ....126.3007R Reid et al., "Meeting the cool neighbors. VII", M dwarfs
2003ApJ...589L..51T Teegarden et al., new very-large-proper-motion star
2003ApJ...594..510B Burgasser et al., T dwarfs in the far-red
2004A&A...416L..17K Kendall et al., M and L dwarfs in DENIS
2004AJ....127.2856B Burgasser et al., T dwarfs and others in 2MASS
2004AJ....127.3553K Knapp et al., near-IR spectra of L and T dwarfs
2004AJ....128..463R Reid et al., "Meeting the cool neighbors. VIII", < 20pc
2005ApJ...623.1115C Cushing et al., R-to-L-band spectra (0.6-4.1 microns)

6.3. Low-mass stars in open clusters

Finally, the pursuit of the bottom of the main sequence in open clusters has likewise benefited from similar deep photometric surveys in the far-red and near-infrared, sometimes combined with proper-motions and x-ray detections. In approximate order of increasing cluster age:

2002A&A...393..195M Marco & Negueruela, PMS candidates in NGC 1893
2005AJ....129..829D Dahm & Simon, T Tauri stars in NGC 2264
2002AJ....124.2083B Balog & Kenyon, emission-line stars in NGC 6871
6.4. Other stars in open clusters

General spectroscopic surveys in open clusters have been used to help separate cluster members from the field and to find interesting targets for more detailed study. Photometry, types, and proper motions by Villanova et al. in the striking high-latitude star-group Collinder 21 show that this is not a physical cluster after all. The dense, obscured cluster Westerlund 1 was worked over several times by Negueruela & Clark, highlighting what a remarkable object it is. The citations below apply to clusters in approximate RA order.

2002AJ....124.507W Walborn, absolute magnitudes of O stars in associations
2002AJ....124.989G Gray & Corbally, peculiar A stars in twelve open clusters
2004A&A...428...67V Villanova et al., Collinder 21 star-group
2005AJ....129..393O Oey et al., IC 1795 and the W3/W4 complex
2002AJ....124.3289B Bragg & Kenyon, Be stars in t & Y & Pl Persei
2002ApJ...576..886S Siesnick et al., mostly hot stars i & Pl Persei
2005ApJ...618L..129K Kalirai et al., white dwarfs in Messier 37
2003MNRAS.341.169B Bosch et al., OB stars near Ruprecht 55
2003A&A...405..570C Corti et al., OB stars near Bochum 7
2005A&A...432.491G Giorgi et al., Pismis 8 and NGC 2866 (Pismis 13)
2002A&A...396L..25C Clark & Negueruela, massive stars in Westerlund 1
2005A&A...434..949C Clark et al., more stars in Westerlund 1
2005A&A...436..541N Negueruela & Clark, still more stars in Westerlund 1
2003A&A...406..893B Boeche et al., NGC 6738 star-group
2004AJ....128..330D Delgado et al., IC 4954/5 = Roslund 4 nebulosity cluster
2004A&A...415..145B Boeche et al., NGC 6913
2004A&A...419..149V Villanova et al., NGC 6997 (not NGC 6996)
2002AJ....124.1585C Contreras et al., intermediate-mass stars in Trumpler 37
2003AJ....126.1415C Caron et al., blue stars in NGC 7419

6.5. Ordinary stars in the field

In this category falls spectral classification of non-pathological stars in the general field — though many have been the subjects of “bandwagon” topics in the past, and perhaps again in the future! The Ginestet & Carquillat paper is the most recent of a series leading to accurate spectral types for binaries with composite spectra. The papers by Abt, by Gray et al., and by Negueruela and colleagues provide detailed MK types “done right” for substantial numbers of stars between roughly mag 6 and 10. At the other extreme, Pirzkal et al. give types for stars 20 magnitudes fainter that appear in the Hubble ‘Ultra Deep Field’.

Classifications for hot degenerate stars, mainly from SDSS spectra, are grouped separately. It has been found that automated classifiers are not yet adequate, and the largest survey here (about 3000 stars by Kleinman et al. 2004) reverts to visual inspection of the digital spectra.

2002ApJ...573..222G Gigoyan et al., late-type field stars
2002ApJS..143..513G Ginestet & Carquillat, composite spectra resolved
6.6. Carbon stars

A third edition of the Stephenson carbon-star catalogue was prepared by Andrejs Alksnis and collaborators in 2001 (2001BaltA..10....1A). It very quickly had updates and amendments resulting from searches at high galactic latitude in SDSS spectra, and from additional spectral surveys of the traditional sort. MacConnell & Osborn recovered Westerlund’s 1100 southern carbon stars using unpublished charts. More ingeniously they found the Smith & Smith late-type stars first published in 1956, completely lacking coordinates, but identified only on a chart of very small scale.

2002AJ....124.1651M Margon et al., high-latitude carbon stars in SSDS
2003AJ....125.2215C Chen & Chen, candidate carbon stars
2003PASP..115..351M MacConnell, southern carbon stars
2004AJ....127.2838M Mauro et al., high-latitude carbon stars in 2MASS
2004AJ....127.2845D Downes et al., more SDSS carbon stars
2005AJ....130..176M Mauro et al., high-latitude carbon stars in 2MASS
2005BaltA..14..144M MacConnell & Osborn, Westerlund carbon stars recovered
2005BaltA..14..148O Osborn et al., Smith & Smith C- and S-type stars recovered
2005BaltA..14..167D Dzervitis & Eglitis, properties of carbon stars in 2MASS

6.7. Massive Stars in the Magellanic Clouds

Classification work in the Magellanic Clouds continues to concentrate on the most massive single and binary stars to explore the upper mass limits of stars. A striking result for O2 stars was the large variations in their N/O ratios, leading to the definition of the ON2−III(+) category. Most notable in this section is the comprehensive survey of over 4000 early-type stars in the SMC made using the 2dF multi-fiber instrument on the 3.9-m Anglo-Australian Telescope.

2002AJ....124.1601W Walborn et al., O stars in 30 Doradus
2003AJ....126..863M Massey & Olsen, red supergiants in the LMC & SMC
2004AJ....137..1087M Martins et al., SMC N81
2004AJ....128..998M Massey et al., early-O stars in the LMC & SMC
2004ApJ...608..1028W Walborn et al., CNO dichotomy in O2 stars in the LMC & SMC and the ON2−III(+) category
2004MNRAS.353..601E Evans et al., 2dF survey of the SMC
6.8. Other Local Group galaxies

The main classification activity here was of Wolf-Rayet stars in M33 and the starburst galaxy IC 10. The more difficult B-supergiants were studied for chemical abundances by Trundle et al.

2002A&A...395..519T Trundle et al., B-type supergiants in four M31 OB assoc
2003A&A...404..483C Crowther et al., WR stars in IC 10
2004A&A...414L..45C Clark & Crowther, one more WR star in IC 10
2004MNRAS.350..552A Abbott et al., WR stars in M33

6.9. Other

In this category falls a variety of classes of objects. Two groups are looking for new Herbig Ae/Be stars throughout the Milky Way. It has become evident that knowing the masses of the cool companions to dwarf novae helps constrain models of the binary and disk. Two examples of classifications of these stars from far-red spectra are cited.

Three unique objects may be singled out during the triennium. First, Ruiz-Lapuente et al. claim to have identified the original companion of a more massive cataclysm, Tycho’s 1572 supernova in Cassiopeia. Next, after nearly a hundred years of suggestions, Comeron & Pasquali seem to have found a likely candidate for the ionizing star of the prominent North America and Pelican Nebulae near Deneb, an overlooked mag 13 late-O star. Third, also long sought, with many candidates not passing muster in the last 50 years, are stars with ‘escape velocity’, i.e., on hyperbolic galactic orbits. The first of these was identified by Brown et al., who suggest its motion is consistent with having been ejected from the Galactic Center.

2003AJ....126.2971V Vieira et al., Herbig Ae/Be candidates
2004AJ....127.1682H Hernandez et al., more Herbig Ae/Be stars
2005AJ....129..856H Hernandez et al., Herbig Ae/Be stars in OB assoc
2003MNRAS.342..151P Putte et al., cool companions of dwarf novae
2004PASP..116..300T Thorstensen et al., cool companions of dwarf novae
2004A&A...427..231G Gorny et al., Wolf-Rayet nuclei of PNe
2004Natur.431.1069R Ruiz-Lapuente et al., Tycho SN progenitor companion?
2005A&A...430..541C Comeron & Pasquali, ionizing star of North America/Pelican
2005ApJ...622L..33B Brown et al., unbound hypervelocity star

7. Photometric Classification
(Vytautas Stražys)

7.1. General Investigations

General investigations related to the determination of stellar parameters by multicolor photometry.

2003A&A...398..705M Melendez & Ramirez, IRFM $T_{\text{eff}}$ calibrations for the Vilnius, Geneva, RJ(C) and DDO photometric systems
2004A&A...417..301R Ramirez & Melendez, IRFM $T_{\text{eff}}$ calibrations for cluster and field giants in the Vilnius, Geneva, RJ(C) and DDO photometric systems
2005ApJ...626..465R Ramirez & Melendez, $T_{\text{eff}}$ scale of FGK stars
7.2. Medium-band Systems

**Strömgren and Vilnius Systems**  Many papers with classifications via the Strömgren and Vilnius systems are covered in section 1 of the report of Commission 25, Stellar Photometry and Polarimetry. Also reported there is the selection of the two “Gaia” systems for classification and parametrization of stars by this orbiting observatory (see [http://www.rssd.esa.int/index.php?project=Gaia](http://www.rssd.esa.int/index.php?project=Gaia)).

Additional papers in the Vilnius system
2005BaltA...14..104Z Zdanavičius, optimum passbands for photometric classification
2004Ap&SS.294...25B Bartašiūte & Tautvaišienė, open cluster NGC 7789
2003BaltA...12..547L Lazauskaitė et al., metal-deficient dwarfs

**Strömgren System**  Investigations in the uvbyβ system include
2002AJ....123.2715T Twarog et al., metallicities of G dwarfs
2002A&A...392.1031A Adelman al, Teff and log g of B and A stars
2002ApJ...577L..45M Martello & Laughlin, metallicity calibration of metal-rich stars
2002RMxAA..38..141M Moreno-Corral et al., open cluster Haffner 19
2002A&A...394..479C Capilla & Fabregat, open cluster h+chi Per
2002RMxAA..39..171S Schuster et al., open cluster NGC 823
2003A&A...403..937P Paunzen et al., open clusters NGC 6192 & NGC 6451
2003AJ....125.1383T Twarog et al., open cluster NGC 6253 (uvbyβ + Ca)
2004AJ....127.1000A Anthony-Twarog & Twarog, open cluster NGC 3680 (uvbyβ + Ca)
2004AAS...205.2207A Anthony-Twarog et al., open clusters NGC 2420 and NGC 6791 (uvbyβ + Ca)
2004AJ....127.1227C Clem et al., color-temperature relation
2004A&A...418..989N Nordström et al., ages and metallicities of Solar vicinity F-G dwarfs
2004A&A...422..527S Schuster et al., stars with very low metallicities: classifications, redenings, ages, ...
2004A&A...426..827B Balaguer-Nunez et al., open clusters NGC 1817 and NGC 1807
2005AJ....129.1642F Fitzpatrick & Massa, calibration of the systems UBV, uvbyβ, Geneva, RJK, 2MASS with Kurucz model atmospheres, B and A stars
2005AJ....129..872A Anthony-Twarog et al., open cluster NGC 2243 (uvbyβ + Ca)
2005MNRAS.358...66F Fabregat & Capilla, open cluster NGC 663
2005RMxAA..41..69M Moreno-Corral et al., open cluster Haffner 18
2005A&A...437..457B Balaguer-Nunez et al., open cluster NGC 2548
2005MNRAS.360.1345K Karatas et al., ages and metallicities of Solar vicinity F-G stars

**DDO System**  Investigations in the DDO photometric system include:
2003A&A...399..543C Claria et al., open cluster IC 2488
2005BaltA...14..301C Claria et al., open cluster NGC 2447

**BATC System**  Investigations in the BATC 15 color photometric system include:
2003A&A...397..361Z Zhou et al., Landolt SA 95 standard star field
2004AJ....128.2265D Du et al., metallicity of F-G dwarfs
2005PASP..117..32W Wu et al., open cluster M48

7.3. Wide-band Systems

Investigations in the UBVRI system are reported in section 1 of the report of Commission 25, Stellar Photometry and Polarimetry. It should be noted that only the Vilnius
system (and partly uvby, DDO and BATC) were used for two- or three-dimensional classification of stars.

Washington System Investigations in the Washington photometric system include:

2002MNRAS.329..556P Piatti et al., LMC clusters NGC 2155 and SL 896
2003A&A...399..543C Claria et al., open cluster IC 2488
2003MNRAS.340.1249P Piatti et al., open cluster NGC 2194
2003MNRAS.341..771G Geisler et al., 8 open clusters in LMC
2003MNRAS.343..851P Piatti et al., star clusters in LMC
2003MNRAS.344..965P Piatti et al., star clusters in LMC
2003MNRAS.346..390P Piatti et al., open cluster NGC 2627
2004MNRAS.349..641P Piatti et al., open cluster Tr 5
2004A&A...418..979P Piatti et al., open cluster NGC 2324
2004A&A...421..991P Piatti et al., open cluster Tombaugh 1
2005BaltA...14..301C Claria et al., open cluster NGC 2447

8. Surveys

8.1. Digitization and Auto-Classification of the Michigan Objective-Prism Plates
(Sang-Gak Lee)
The main goals of the project are first, to digitize all deep Michigan objective-prism plates, second, to auto-classify them. The deep (20 min exposure) plates of about 1000 excellent plates, covering the southern whole sky lower than the declination of +3.5 degree, were shipped to the Astronomy Department of Seoul National University for a long-term loan from Dr. Nancy Houk at Michigan University in Oct 2003.

Michigan objective-prism plates were taken with the Michigan Curtis Schmidt (36/24 inch) telescope at Cerro Tololo Inter-American Observatory. The 4° × 6° prisms yield a dispersion of 108 Å/mm at H and the resolution is about 2 Å. The spectra were taken on IIa-O plates and widened to 0.8 mm and exposed 20 min. Each plate covers 5° × 5° field of view (19.5 cm × 19.5 cm) and contains good spectra of most HD stars in each field. HD stars were reclassified visually on the objective-prism plates by Houk and catalogued in five volumes of the Michigan Spectral Catalogue.

Unfortunately the budget request for the renovation of the originally proposed microdensitometer PDS 2020 GMS at the Seoul National University for the PC-based data acquisition system was rejected in 2004, and the positioning accuracy of the microdensitometer PDS 1010 GMS at the Korea Astronomy Observatory is so poor that one has to do it manually.

Therefore a commercial scanner, Microtek ScanMaker i900 and a dedicated PC have been purchased for this project. The ScanMaker i900 is a 48-bit, high-speed color (16-bit grey scale) scanner featuring a dual interface (FireWire and Hi-Speed USB), 6400 × 3200-dpi optical resolution, and two scanning beds: an upper bed for scanning reflective materials and a lower bed for scanning transparent materials such as glass plates. Tests have shown that the spatial resolution of 8 μ/px by the scanning resolution of 3200 dpi is appropriate for the 108 Å/mm dispersion objective-prism plates with 2 Å resolution. With 3200 dpi scanning resolution, the scanning time and the file size for a 19.5 cm × 19.5 cm plate are about 30 min and 1.2 Gb. It is expected to complete scanning for 1000 plates by the end of this year.

The future plan is to make a spectrum file for each HD star on all of the Michigan
objective-prism plates. This will include a one-dimensional wavelength calibrated spectrum, which will be available publicly and will be used for auto-classification.

8.2. The COROT Mission

(Werner W. Weiss)
COROT (Convection Rotatation and Transits of planets) is a French led European space mission designed for ultra-precise photometry and is scheduled for launch in summer 2006. The scientific goals are twofold: asteroseismology of stars brighter than 9th magnitude, and detection of planet transits for stars in the magnitude range from 11th to 16th V-magnitude. For the latter, CoRoT will continuously measure the fluxes of up to 12,000 stars selected in a field of view of about 3.4 square degrees. Two fields in opposite directions in the sky and close to the galactic and celestial equator will be observed continuously during 150 days providing a total of 60,000 light curves. In addition, two other fields will be observed during a shorter period of about 20 days, adding another 60,000 light curves, but with a shorter time coverage.

The knowledge of fundamental astrophysical parameters for each of the candidate targets is required not only for a selection of the best targets within each exoplanet target field, but also for assigning the optimum photometric window for the CCD detector. Due to a direct vision prism in front of the CCDs of the exoplanet channel, the point spread function depends on the spectral type and magnitude of a target star. A large program of broad-band photometry with the INT/La Palma has been performed and cross-correlated with near-IR 2MASS data to obtain this information. However, this photometric classification suffers from large uncertainties, the main being unknown reddening which can result in a wrong identification of the luminosity class. In addition, photometry does not provide a good estimate for metallicity nor for binarity. Test observations have been obtained and a full proposal has been submitted for using the GIRAFFE/VLT large field multi-fiber facility at ESO to characterize the bright dwarf population in the CoRoT exoplanet fields. The immediate objective of this programme is to derive fundamental stellar parameters for a large sample of about 24,500 dwarfs, selected among target stars brighter in R than 15 mag. The planned classification survey aims at building a complete database of stellar properties needed for investigating the properties of extra-solar systems and the mechanism of formation of the planets which will be found by CoRoT.

9. Conferences

Five members of Commission 45’s OC initiated a proposal for a Joint Discussion, "Exploiting large surveys for Galactic astronomy". They were joined by members from five other Commissions, and all were delighted to have the proposal accepted as JD13 during the XXVth IAU-GA in Prague.

Acknowledgements

I am very grateful to all those colleagues whose names appear at the head of the sections they contributed to this report. I also wish to thank the OC members for their support and in particular the members of the JD13 SOC for their patient and considerable work.

Christopher J. Corbally, S.J.
President of the Commission
Division IV Working Group on Abundances in Red Giants

CHAIRPERSON: John C. Lattanzio
ORGANIZING COMMITTEE: Pavel Denissenkov, Roberto Gallino, Josef Hron, Uffe Graae Jørgensen, Claudine Kahane, Sun Kwok, Verne Smith, Christopher Tout, Robert F. Wing, Ernst Zinner

Abstract. Determining and understanding the abundances seen in red-giant stars has taken a central role in our understanding of many branches of modern astrophysics. Activity in the area continues apace, both in terms of the fundamental physics of the stellar nucleosynthesis as well as its implications for wider fields. A major role of the Working Group has been to facilitate meetings where the fundamental role of these stars can be further understood and exploited by other researchers.

1. Introduction and History

The Working Group on Abundances in Red-Giants was proposed in March 2001 and formally accepted as a Working Group of Division IV in June that year. Our prime aims at the time were a) to enhance communication among interested researchers by email lists, b) to set up a new web site for posting relevant announcements, data sets, etc. and c) to prepare a proposal for a symposium during the General Assembly in Sydney. Each of these was achieved. The proposed Symposium for the GA in Sydney was not supported, but we have since then been involved in many activities including two meetings as detailed below.

2. Organization of the Working Group

The Organizing Committee consists of eleven scientists from nine different countries, giving us true international coverage. We also cover those discipline areas most related to the fundamental physics of red-giant nucleosynthesis, but are very much aware of the role they play in the broader context of modern astrophysics. Such a role is emphasized wherever possible.

We maintain an email list for rapid communication among interested persons. This list currently holds addresses for of 63 individuals, a little more than twice the number involved at the time of the last triennial report. These individuals represent twenty different countries. A website for the WG is maintained at


Some members had requested a Wiki web-page or something of that sort. We tried a “Dassie” page to help organize the meetings below but found that few people used the software, so we continue to use email as the best form of communication within the WG.

Our webpage provides links to some software developments. For example, Dr Robert Izzard is developing an abundance database and that is accessible from the WGARG page. This should be very valuable for all members of this WG.
2.1. Meetings

The organization and promotion of international meetings was one of the main reasons for the formation of this WG and we have been active in this area. We have organized one two week workshop in 2005, as well as a Joint Discussion at the upcoming IAU in Prague in 2006. We are also co-sponsors of a meeting in Vienna in 2006.

2.2. Lorentz Centre: “Nucleosynthesis in Binary Stars”

Following a business meeting of the Working Group at the IAU GA in Sydney it was decided to apply for funding to hold a workshop at the Lorentz Centre, in Leiden. A sub-committee prepared a proposal to hold a workshop of two weeks duration at the Centre. Supplementary funding was secured from other sources in The Netherlands. It was thought that it was timely to discuss the combination of modern nucleosynthesis with the evolution of binary stars. It is likely that continued improvements in computer power will mean that some of the more long-standing problems in these areas will be approachable soon, and the workshop was designed to identify areas where effort should be directed.

The meeting took place in Leiden from April 4 to 15, and attracted 34 participants during its two-weeks. One of the areas that attracted much activity was a detailed comparison of various evolutionary codes currently in use. The results from this comparison are to be prepared for publication. The workshop allowed for summary talks of current knowledge as well as areas requiring more work, and the discussions were very active and animated. It is proposed that a follow-up meeting be held in the future.

2.3. IAU GA in Prague: JD 11 on “Pre-Solar Grains as Astrophysical Tools”

The analysis of pre-solar grains continues to be a rich source of data for stellar nucleosynthesis and galactic chemical evolution. To ensure that more researchers are aware of the insights provided by this field, we proposed a Joint Discussion to be held at the upcoming IAU GA in Prague in 2006. This has been approved and we are in the process of finalising speakers and calling for contributions.

2.4. Vienna Aug 2006: “Why Galaxies Care About AGB Stars”

Partially inspired by some of the discussions within our WG, the group at the University of Vienna will hold a meeting just prior to the IAU GA in 2006. This meeting aims to build a bridge between AGB research and its application to the modelling of stellar populations and the chemical evolution of galaxies. Our WG is a co-sponsor of the meeting and provides one Organizing Committee member on the SOC for the meeting.

3. Scientific Developments

3.1. Globular Clusters

The various abundance anomalies in globular clusters still demand an explanation. Recent observations of fluorine show that this element can now be added to those showing variations from star-to-star within a cluster. With most of the abundance anomalies now shown to occur on the main sequence, the belief is that a pollution scenario is responsible although no consensus has yet arisen concerning the nature of the polluting stars. Although AGB stars are often cited, conclusive proof is still required, and model predictions depend on uncertainties in convection models, for example.
3.2. Pre-Solar Grains

Presolar oxide grains provide growing evidence for extra deep mixing (also called cool bottom processing) in AGB stars. Both the large \(^{18}\text{O}\) depletions found in many oxide grains and the high inferred \(^{26}\text{Al}/^{27}\text{Al}\) ratios require processes beyond the standard stellar evolution and nucleosynthesis models for AGB stars. It is puzzling that presolar SiC grains from AGB stars have, on average, much smaller \(^{26}\text{Al}/^{27}\text{Al}\) ratios than oxide grains and do not require any extra mixing processes. This observation runs counter to the expectation that, after sufficient third dredge-up, O-rich AGB stars that produced the oxide grains turn into carbon stars from which SiC grains can condense and that these grains also have high \(^{26}\text{Al}/^{27}\text{Al}\) ratios. It might be that extra mixing keeps O-rich stars from turning into carbon stars. However, cool bottom processing is not well understood on a fundamental level and much work remains to clarify this situation. Recent measurements of Ru isotopic ratios in presolar SiC grains from C-rich AGB stars found an s-process pattern except for systematic excesses in \(^{99}\text{Ru}\). These excesses have been taken as evidence for the presence of \(^{99}\text{Tc}\) in the grains at the time of their formation. It is satisfying that more than half a century after the astronomical observation of Tc in the atmosphere of S stars provided evidence for stellar nucleosynthesis we now find evidence for the initial presence of Tc in tiny specks of stardust we can study in the laboratory.

3.3. Nuclear Physics

The interaction between the astrophysics community and the nuclear physicists has perhaps never been stronger than it is at present, largely due to the demands of modern nucleosynthesis. The bi-annual meetings on “Nuclei in the Cosmos” bring together researchers from both fields, and stimulate new experiments, calculations and observations. This continues, with the next meeting in the series planned for CERN in July 2006.

4. Looking Forward

Red-giants continue to play a central role in many fields of modern astrophysical research. The strong interaction between nuclear physics (experimental and theoretical) and stellar astrophysics (both observational and theoretical) is proof of a vibrant working environment. The many international meetings each year attest to the activity, be it inquiry into the red-giants themselves or implications from them for other areas of astronomy. Interest in these objects shows no sign of diminishing yet.

John C. Lattanzio
Chairperson of the Working Group
Division IV Working Group on Massive Stars

CHAIRPERSON: Claus Leitherer
ORGANIZING COMMITTEE: Paul Crowther, Philippe Eenens, Alex Fullerton, Gloria Koenigsberger, Phil Massey, George Meynet, Tony Moffat, Stan Owocki, and Joachim Puls

Abstract. This report covers the activity period 2002 – 2005 of the IAU Working Group on Massive Stars

1. Mission Statement
Our group’s focus is the study of massive stars, both individually and in resolved and unresolved populations. These objects populate the upper part of the Hertzsprung-Russell diagram. On the main-sequence these stars are spectroscopically identified as types O and early B, while later evolutionary stages encompass supergiants and Wolf-Rayet stars. Our group also studies some stars of lower mass, which may show many features similar or related to those present in massive stars, and thus may improve our understanding of the physical processes occurring in massive stars.

2. Organizational Matters
The members of the Working Group elected Paul Crowther, Alex Fullerton, Gloria Koenigsberger, Claus Leitherer, Phil Massey, George Meynet, and Joachim Puls into the Organizing Committee (OC). The new OC members joined Tony Moffat, Stan Owocki, and Philippe Eenens who are still completing their terms in the 10-person OC. The OC then elected Claus Leitherer as Chairperson.

After thorough debate, the OC voted for a name change of the Working Group from "Hot Massive Stars" to "Massive Stars". This name change reflects the tight interrelation of research on hot and cool stars in the upper Hertzsprung-Russell diagram (see below).

The OC created and approved a set of by-laws. The by-laws are posted on the Working Group website at http://www.astroscu.unam.mx/massive_stars/.

The distribution list of our members and their e-mail addresses was updated. As of 2005, there are 429 members in the Working Group at research and educational institutions.

3. Website Development
A new web portal was designed and implemented on a server located at UNAM (http://www.astroscu.unam.mx/massive_stars/). After an open call soliciting expressions of interest, the OC was pleased to select Raphael Hirschi (University of Basel) as the new webmaster. Back issues are posted on the Working Group website and provide an invaluable record of scientific developments in the field, particularly the emergence of new "hot topics”.

Among other innovations, the new web portal offers a discussion group page and an automatic Newsletter submission interface. This new interface allows the members of
the Working Group to submit their Newsletter abstracts and circulates newly received abstracts to registered members.

4. Science Support

The Massive Star Newsletter, edited by Philippe Eenens, continues to be the main means of communication and science dissemination in our Working Group. As of October 2005, 87 issues of the Newsletter have been published. Back issues are posted on the Working Group website.

The OC is currently discussing routes to foster more interactions between researchers working on hot and cool massive stars. Scientific areas that would benefit from such a dialog are the evolutionary relation between the hot and the cool part of the HRD, W-R/LBV progenitors, dust formation in RSG/AGB vs. W-R stars, wind hydrodynamics, or abundance determinations from hot vs. cool stars.

A second area of research with a strong need for interaction concerns rotating stars. Recent work by the Geneva group points to the likelihood that rotational spin-up plays an important role in the evolution of massive stars. Be stars may be a key laboratory for studying its nature and consequences.

The OC is concerned about a fair gender and ethnic representation in committees and initiatives of interest to our Working Group. The OC feels the best way to promote a fair representation is to encourage its members from minority groups to actively volunteer for service. This is particular relevant for junior members, who tend to be underrepresented. A major challenge for the WG is to improve its visibility with our junior members and with the community at large. Many junior massive-star researchers are not aware of the efforts of the Working Group, and they do not know the decision making process. The OC should leverage the enormous scientific potential of our members in order to advance our field of research.

5. Conference Planning

A proposal for a Joint Discussion during the XXVIth General Assembly by several OC members was accepted by the IAU. The 1-day meeting Calibrating the Top of the Stellar Mass-Luminosity Relation is planned for August 16, 2006. The goal of this Joint Discussion is to bring together theorists and observers from the stellar and extragalactic communities to discuss the properties of the most massive stars and the implications for cosmological studies. The meeting will focus on a set of themes that follow from fundamental stellar astronomy, such as mass determinations in binary stars, to recent modeling of atmospheres and evolution, to the significance of massive stars for the ecology of the host galaxy, and finally to a critical assessment of the properties of the first generation of stars in the universe. The meeting organizers are Norbert Langer, Claus Leitherer (Chair), Tony Moffat, Stan Owocki, and Joachim Puls. The website is http://www.stsci.edu/science/starburst/Prague/.

The OC supported a proposal for a planned IAU symposium entitled "Massive Stars as Cosmic Engines" to be held on Kanai (Hawaii, USA) between December 10 – 14, 2007.

The theme of the conference will be how massive stars shape the universe from the nearby universe to high redshift galaxies. They form in starbursts, chemically enrich the interstellar medium, inject energy via their stellar winds and core-collapse supernovae, drive the interstellar medium out of galaxies, enriching the intergalactic medium. The major observational constraints at high redshift, Lyman-break galaxies and damped
Lyman-α absorbers, are direct detection of massive stars via their UV continua and stellar winds and indirectly via the ionized ISM. Paul Crowther and Joachim Puls are the co-chairs of the SOC.

Acknowledgements

The OC gratefully acknowledges logistic support for several teleconferences by STScI. The Institute of Astronomy of UNAM provided a new disk drive in support of the web server. UNAM and STScI provided technical support through Liliana Hernandez and Julia Chen.

Claus Leitherer
Chairperson of the Working Group
Division IV/V Working Group on
Active OB Stars

CHAIRPERSON: Stan Owocki
ORGANIZING COMMITTEE: Conny Aerts, Juan Fabregat,
Doug Gies, Huib Henrichs, David McDavid, John Porter,
Thomas Rivinius. Advisors: Gerrie Peters, Stan Stefl

1. Working Group Focus

Our group studies active early-type (OB) stars, with historical focus on classical Be stars, but extending in recent years to include Slowly Pulsating B-stars (SPB), Beta-Cephei stars, the strongly magnetic Bp stars, Luminous Blue Variable (LBV) stars, and B[e] stars. An overall goal is to understand the nature, origin, and consequences of this activity, in terms of both the stellar structure and evolution, as well as the distribution and dynamics of circumstellar material and mass outflows.

2. Scientific Meetings

Research activity within our WG during the past triennial period of 2002-2005 was highlighted by 3 topical meetings:


(c) “Active OB Stars: Laboratories for Stellar and Circumstellar Physics”, held in Sapporo, Japan at the end of August 2005, with the SOC co-chaired by Stan Stefl and Stan Owocki and SOC members Conny Aerts, Dietrich Baade, Jon Bjorkman, Mike Marlbrough, Ignacio Negueruela, Atsuo Okazaki, Phillippe Stee and Rich Townsend. The conference honored the many scientific contributions to our field by Ryuho Hirata, Anne-Marie Hubert, and Mike Marlbrough. The proceedings will be dedicated to the memory of John Porter (see below).

A common theme in all three meetings was the origin of the circumstellar disks inferred in both Be and B[e] stars, with particular focus on the relative roles of rapid (perhaps near-critical) stellar rotation, stellar pulsation, and stellar magnetic fields.

In addition to these topical meetings, there was a one-day meeting of the WG held at the 25th IAU General Assembly in Sydney, consisting of both a business and science session. A summary of the outcome is given in volume 37 of the Be-Star Newsletter, which is available online via the link given below.

3. Newsletter

Developments in our field are reported in the Be-Star Newsletter, for which the electronic version is updated as needed upon submission of new materials, and printed edi-
tions published bi-annually. Geraldine Peters is editor-in-chief of the Newsletter, Doug Gies manages the hardcopy publication, and David McDavid is the webmaster. The URL is:

http://www.astro.virginia.edu/~dam3ma/benews/

4. Community Loss

In June 2005, the members of our Working Group were saddened to learn of the sudden death of John Porter, at age 37. A valued member of our Organizing Committee, John was an innovative researcher on Active OB stars, authoring numerous influential papers, including a recent general PASP review on Be stars. Our community will sorely miss his keen insight, his gentle humor, and his warm, friendly face.

Stan Owocki
Chairperson of the Working Group
Division IV/V Working Group on Chemically Peculiar and Related Stars

CHAIRPERSON: Werner W. Weiss

A meeting of the IAU Working Group on Chemically Peculiar and Related Stars was held in Sydney on July 16th, 2003. The focus of the business session was on possible effects on our WG due to plans for restructuring the IAU. Working Groups are to be evaluated every 3 years and in general, will be limited to a period of 3 or 6 years.

Thanks to the very efficient WG Newsletter (http://www.astro.uwo.ca/apn or http://www.eso.org/apn), it was felt that the scientific activities of the community and the communication between the members does not depend much on the existence of an IAU-WG. However, if it comes to raising funds for a conference, a workshop or any activities requiring contacts to governmental or other administrative bodies, it certainly is advantageous to have an international organisation as a background. This Peculiar Newsletter was founded 1978 in Vienna as a communication tool for the European Ap-WG. The first editors were H. Hensberge, Gh. Deridder and W. van Rensbergen who stayed on this duty until early 1992, except of Deridder who left the team in mid-1983.

As a consequence, it was requested that the Working Group on Chemically Peculiar and Related Stars be promoted from a Commission WG (presently of Commission 45 - Stellar Classification) to the Division level. In one of its last sessions in Sydney, the IAU Executive Committee granted this request and decided that our WG will be now hosted by two Divisions: Division IV (Stars) and Division V (Variable Stars).

The very positive attitude of the IAU Executive Committee towards our WG was also reflected by the approval of IAU-Symposium 224 on “The A-Star Puzzle” in July 2004, at High Tatras, Slovakia.

In the same spirit, the Working Group sponsored or participated in the organisation of the following conferences:

- International Conference on “Magnetic Stars”, Nizhnij Arkhyz, Special Astrophysical Observatory, August 2003, Russia.
- International Conference on “Element stratification in stars - 40 years of atomic diffusion”, Mons, June 2005, France.
- Workshop on “ATLAS12 and Related Codes”, Trieste, July 2005, Italy.

While not organized by the WG, the idea was born out of discussions started at IAU-Symp. 224, to propose a conference on “Convection in Astrophysics”, which will be IAU Symp. 329, Prague, August 2006, Czech Republic.

A similar proposal of the WG for a Symposium during the GA 2006 on “Chemically Peculiar Stars”, unfortunately, did not receive support.

The Vienna Atomic Line Data base (VALD, http://ams.astro.univie.ac.at/vald/) developed as a successful multi-countries cooperation to a much demanded tool for spectroscopists under the patronage of the Working Group.

Werner W. Weiss
Institute for Astronomy, Vienna, Austria
Chairperson of the Working Group

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