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COMMISSION 29 STELLAR SPECTRA

Spectres des etoiles

TRIENNIAL REPORT 2009-2012

1. Introduction

Commission 29 consists of members of the International Astronomical Union carrying out theoretical and observational studies of stars using spectroscopy, developing instrumentation for spectroscopy and producing and collecting data for interpretation of spectra.

Specific interests range from classical abundance analysis to stellar evolution, dynamics and structure formation in and around stars. In the past three years the work of the Commission, carried out primarily by the organizing committee (OC), was focused on establishing the right balance and interaction format with other IAU commissions and working groups dealing with overlapping matters. The OC also dealt with routine matters that fall under the competence of the Commission. In particular, the OC has discussed and ranked proposals for several IAU sponsored meetings. The Commission participated in the organization of a number of Symposia, Joint Discussions, and Special Sessions held during the 26th IAU General Assembly at Rio in August 2009. Commission members themselves initiated and actively participated in organizing IAU sponsored meetings.

Commission 29 belongs to the IAU Division IV (Stars), dedicated to stellar analysis, stellar interior and atmospheric structure and evolution of stars of various masses, ages, and chemical compositions. Besides Commission 29, Division IV hosts Commissions 26 - Double and Multiple Stars, 35 - Stellar Constitution, 36 - Theory of Stellar Atmospheres, and 45 - Stellar Classification. The work conducted across commission competences is coordinated by working groups (WGs). Division IV has four working groups: WG on Active B Stars, WG on Massive Stars, WG on Red Giant Abundances, and WG on Chemically Peculiar and Related Stars.

2. Recent and approved IAU meetings endorsed by Commission 29

IAUS 272: Active OB stars - structure, evolution, mass loss, and critical limits, Paris, France, 19-23 July, 2010

IAUS 273: Physics of Sun and star spots, Los Angeles, USA, 23-26 August, 2010

IAUS 282: From Interacting Binaries to Exoplanets: Essential Modeling Tools, Tatranska Lomnica, Slovakia, 18-22 July, 2011

IAUS 294: Solar and astrophysical dynamos and magnetic activity, Beijing, China, 27-31 August 2012

SpS13: High-precision tests of stellar physics from high-precision photometry, Beijing China, 27-31 August, 2012

3. Scientific highlights

Stellar spectroscopy remains one of the most active fields of astrophysics with over 8000 papers published just in refereed journals during the reporting period. This can be attributed, in part, to continuous technology development (larger telescopes and better detectors help reaching more objects and with higher resolution) and, in part, to closer integration of fields within astrophysics (e.g. stars and planets through exoplanet research). Thus, in preparing this report we choose to present the advances in stellar spectroscopy in the form of highlights rather than producing an exhaustive report.

3.1. *Exoplanets and planet host stars*

The Kepler mission is producing hundreds of transiting exoplanet candidates each month, setting pressure on spectroscopic confirmation but also opening new opportunities for characterization. Multiple groups work on systematic spectroscopic follow-ups of the CoRoT and Kepler transit candidates. The task is not easy as the majority of targets are very faint; however, the combination of photometric light curve and spectroscopic characterization of the host star allows unambiguous determination of planetary mass and density (e.g. Leger 2009; Rouan 2011). Several papers described the methodology and results of chemical characterization of exoplanets. Today such analysis is only possible for either young (hot) planets in large orbits (e.g. Barman 2011) or for close-in massive planets using transit/eclipse spectroscopy (e.g. O'Donovan 2010; Moses 2011). Correlation between stellar chemical composition and the presence of planets remains a hot topic in stellar spectroscopy after the pioneering work by Fischer and Valenti (2005). Preliminary results extending their work to lower-mass stars have been presented at conferences and we expect new statistically sound surveys to be published soon.

3.2. *Fundamental stellar parameters*

The comparison of various analysis techniques indicates the main sources of uncertainty in determining fundamental stellar parameters (effective temperature, surface gravity and chemical composition) are the atomic and molecular data and the model atmospheres. This is a clear case where the interests of Commission 29 overlap with other commissions. Systematic studies of chemical composition were performed across various stellar associations or populations (e.g. Gonzalez 2011; Bensby 2010). The search for the oldest stars continues with the latest instrumentation (e.g. Caffau 2011; Hansen 2011). The most advanced simulations accounting for non-equilibrium effects and 3D dynamics in stellar atmospheres show progress, although the convergence between different groups and the helioseismology results are still somewhere in the future.

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3.3. *Magnetic fields and structures in stellar atmospheres*

Studies of magnetic fields and application of Doppler imaging reached new qualitative levels. The new spectropolarimeters, such as ESPaDOnS, NARVAL and HARPSpol, when combined with advanced data analysis techniques reach unprecedented detection levels of 1-2 Gauss (e.g. Petit 2010; Kochukhov 2011a), making possible direct studies of activity on solar-type stars of various ages and stars hosting planets. The detection surveys are conducted by large international consortia. This work generated over one hundred refereed papers in the last three years.

Noticeable rotational modulation of spectral line profiles offers a possibility of investigating structures on stellar surfaces using Doppler imaging techniques. Such an approach was used for mapping chemical spots on chemically peculiar (CP) stars and temperature spots on cool stars. Series of Doppler images were used to detect and measure differential rotation (Korhonen 2011; Waite 2011). Temporal evolution of chemical spots on CP stars was unambiguously established. Often, when magnetic fields are detectable in these objects various flavours of magnetic Doppler imaging were used to establish the relation between the field and the spots (Kochukhov 2011b).

3.4. *New instrumentation*

The work on new spectroscopic instrumentation is progressing along three lines: stability, wavelength coverage and combination of techniques. The work on stability aims at reaching reproducibility of radial velocity measurements at the 10 cm/s level on the baseline of a few years. The focus is on stabilizing the light entering a spectrometer (e.g. by employing unconventional fibers to improve the scrambling), on better calibrations (gas cells, simultaneous wavelength references such as Fabry-Perot etalon or frequency comb), and on the analysis software (replacing the analysis of multiple short wavelength intervals by modelling of the entire focal plane). Several applications require a combination of high throughput and very large wavelength coverage, as answered by instruments such as the VLT X-shooter (Vernet 2010). Finally, we see a significant growth of results based on the combination of techniques. Studies of giant stars with spectrally-resolved interferometry (e.g. Paladini 2011) complemented by the theoretical 3D models (Chiavassa 2011) illustrate the productivity of such an approach.

4. Closing remarks

The current tendency for combining different techniques for the same objects and covering different objects with similar methods is not reflected by the interaction mechanisms between the commissions within IAU divisions or even between divisions. The question will be addressed during the GA in Beijing. Changes in the IAU division structure are urgently needed.

Nikolai Piskunov
president of the Commission

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