Transactions IAU, Volume XXXA
Reports on Astronomy 2015-2018
Piero Benvenuti, ed.

DOI: 00.0000/X000000000000000X

DIVISION G / WORKING GROUP Ap AND RELATED STARS

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TRIENNIAL REPORT 2015-2018

1. Introduction

The purpose of the Working Group on Ap and Related Stars (ApWG) is to promote and facilitate research about stars in the spectral type range from mid-B to early F that exhibit surface chemical peculiarities and related phenomena. To achieve this objective, the ApWG publishes a newsletter and distributes it to its members, and the WG members actively contribute to the organisation of international scientific meetings. More details about those activities are presented in Sections 3 and 4 of this report, following an overview of some of the main scientific highlights of the past three years in the field of the Ap and related stars (Section 2).

2. Scientific highlights

The Ap and related stars continue to be a very active field of research, and many new results of great interest were published over the past triennium. In the limited space of this report, only a few highlights can be presented. Unavoidably, this selection involves a significant degree of arbitrariness, which does not imply any negative judgement about the works that could not be mentioned.

Classical Ap stars have long been known to host strong large-scale organised magnetic fields. The major surveys MIMES (Grunhut et al. 2017) and BOB (Schöller et al. 2017) establish that such fields are actually present in a fraction of all upper main sequence stars from early F to O types, putting the magnetism of Ap stars in a broader context. Studies of the magnetic properties of those stars continue to be carried out by various groups. Systematic surveys increase the number of known magnetic Ap stars and improve the characterisation of their variations (Romanyuk 2015, 2016, 2017; Romanyuk et al. 2015, 2016, 2017). A growing number of increasingly refined maps of both the magnetic structures of Ap stars and the distribution of the chemical elements over their surfaces are being derived by application of the Zeeman Doppler Imaging technique (Silvester et al. 2015, 2017; Rusomarov et al. 2016, 2018). The diagnostic potential and the limitations of various approaches to deriving such maps, both with and without magnetic fields, continue to be studied (Kochukhov 2017; Stift & Leone 2017a,b). The new chemical abundance maps lend themselves to comparison (Kochukhov & Ryabchikova 2018) with the predictions of the theory of time-dependent atomic diffusion (Alecian 2015; Stift & Alecian 2016).

The long-term monitoring of the magnetic variations of strongly magnetic Ap stars that rotate extremely slowly (Mathys 2017) reveals that up to 10% of the Ap stars have periods longer than one month (up to several centuries), and hints at the existence of systematic differences of the magnetic properties between the long and short period stars. While magnetic field measurements are particularly well suited to follow up variations over several years, photometric monitoring is very useful to complement them (Mathys et al. 2016), or as an economical alternative when the amplitudes of variations are large enough (Pyper & Adelman 2017). On the other hand, photometry remains the tool of choice for systematic variability surveys, especially taking advantage of the databases from large automated surveys such as ASAS-3 and SuperWASP (Bernhard et al. 2015a,b). The numerous new periods and lightcurves derived from those data enable new statistical studies of the rotational properties of Ap stars and of their relations with other properties of those stars (Netopil et al. 2017).

Kepler, now executing the K2 mission, continues to deliver a wealth of data that are extremely useful for various types of studies of Ap and related stars. Asteroseismology of those stars is, of course, a field of choice for exploitation of the Kepler data. Noteworthy recent works in this area include extensive studies of statistical samples of δ Sct stars, which in particular emphasise the value of those stars for the knowedge of rotation and angular momentum transport in A and F stars (Bowman et al. 2016; Bowman & Kurtz 2018); and the discovery of a rapidly oscillating Ap (roAp) star pulsating in a distorted quadrupole mode (Holdsworth et al. 2016). More generally, Kepler data reveal that many apparently normal A stars show low amplitude variations, including both periodic variations and transients. The interpretations of the latter as due to the occurrence of flare in A stars (Balona et al. 2016) and of the former as related to the presence of starspots on those stars (Balona 2017), suggesting that A stars may display stellar activity, are debated (Pedersen et al. 2017). In particular, theoretically predicted r-mode oscillations (global Rossby waves) may account for periodic variations at an approximate stellar rotation rate (Saio et al. 2018).

Ground-based surveys also continue to be exploited for asteroseismological purposes. The study of a large sample of A and Am stars observed with LAMOST and with WASP reveals that the incidence of pulsation in Am stars decreases with increasing metallicity, and provides evidence that turbulent pressure is the main driving mechanism in pulsating Am stars (Smalley et al. 2017).

Thanks to the ever-increasing sensitivity of spectropolarimeters, very weak magnetic fields start to be detected in a growing number of A stars besides the classical Ap stars. The discovery of sub-G magnetic fields in two Am stars and of a $\sim 30\,\mathrm{G}$ magnetic field in a third one (Blazère et al. 2016a,b) strengthens the earlier conclusion that Sirius A, a hot Am star, also has a weak magnetic field (Petit et al. 2011). The mapping of the distribution of the spots on the surface of Vega and the study of the evolution of this distribution provide additional insight into the physics related to the presence of a very weak magnetic field in this prototypical A star (Petit et al. 2017). Recently discovered weakly magnetic A supergiants are the likely descendants of main-sequence magnetic B stars (Neiner et al. 2017).

Optical interferometry is also a powerful technique to study various aspects of Ap and related stars. Most fundamentally, it is used to determine the effective temperatures of a sample of roAp stars (Perraut et al. 2016), and to derive the orbital parameters of a HgMn binary and the masses of its components (Hummel et al. 2017). The potential of interferometry to map the spots on the surfaces of Ap stars is also starting to be exploited (Stée et al. 2017).

3. A peculiar Newsletter

The newsletter of the ApWG, *A peculiar Newsletter* (ApN) is published electronically and freely accessible at http://apn.arm.ac.uk/newsletter/. It serves as a reference source for the most recent publications in the research field of Ap and related stars, as a board for announcements of interest for the scientific community working in this field (including e.g. conference announcements, job ads, and obituaries), and as a forum for discussion among members of this community. Every time a new contribution is added, a notification email is sent to all members of the ApWG to alert them about it. Accordingly, the ApN represents a very valuable channel of communication and of reference for the scientists interested in Ap and related stars.

4. Scientific meetings

In line with a long-standing tradition of semi-regular major meetings on Ap and related stars, and with a view to broadening the scientific scope of this meeting series, a group of ApWG members led the organisation of a conference on *Stars with a stable magnetic field: from pre-main sequence to compact remnants*. This conference, which took place in Brno (Czech Republic) in 2017, gathered 80 participants who reviewed our current knowledge, both observational and theoretical, of the magnetic properties of stars from molecular clouds and pre-main sequence stars to the final stages of white dwarfs and neutron stars through the classical Ap star stage, with a view to understanding the evolutionary connections between those different stages. The proceedings were recently published (Contributions of the Astronomical Observatory Skalnaté Pleso, Volume 48, Number 1, 2018).

A number of other international meetings that include sessions relevant to the physics of Ap and related stars and to the organisation of which ApWG members contributed, took place, or will take place, between August 2015 and October 2018. They include: *Magnetic intermediate mass stars* (Bagnères de Bigorre, France, Jamuary 2016); *Understanding the roles of rotation, pulsation and chemical peculiarities in the upper main sequence* (Lake District, UK, September 2016); *Stellar Magnetism: Challenges, Connections, and Prospects* (Potsdam, Germany, June 2017); *IAU Symposium 339: Southern Horizons in Time-Domain Astronomy* (Stellenbosch, South Africa, November 2017); *The TASC4/KASC11 workshop: First Light in a new Era of Astrophysics* (Aarhus, Denmark, July 2018); *What physics can we learn from oscillating stars?* (Banyuls, France, September 2018); *Physics of Magnetic Stars* (Nizhniy Arkhyz, Russia, October 2018).

5. Closing remarks

The selected scientific highlights presented in this report witness to the healthily active state of research in the field of Ap and related stars. The community working in this field is taking full advantage of the new observing capabilities that enable new types of studies and deliver data of unprecedented quality, and it exploits the wealth of information contained in the products of large surveys. Those trends will undoubtedly continue in the coming years. The exploitation of the data recorded with exquisite precision in the four Stokes parameters with the most modern spectropolarimeters (ESPaDOnS, NARVAL, HARPSpol) is only starting, and the scope of this observation technique will be further broadened by the imminent entry into operations of the unique infrared spectropolarimeter SPIRou at the CFHT †. New developments in high-resolution spectrographs, such as the ultra-stable ESPRESSO (Pepe et al. 2013) and NIRPS, the infrared arm of HARPS ‡, both at ESO, open tantalising new prospects. The push for an interferometric instrument in visible light (Stée et al. 2017) will open the possibility of the first direct observations of the spots on the surfaces of Ap stars. During its mission, the soon-to-be-launched TESS will observe a large number of Ap and related stars and provide a unique, homogeneous sample of data for systematic studies of the physical processes taking place in those stars, including, but not restricted to, their asteroseismological behaviour. These are but a few examples.

Within this context, the role of the ApWG and of the ApN will be more essential than ever, to maintain a fluid and effective flow of information among the members of the community working in the field of Ap and related stars, to ensure that they have optimum access to the information relevant to their research projects, and to provide them with forums to exchange their views and their results.

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