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DIVISION G / WORKING GROUP Ap AND RELATED STARS

CHAIR	**Barry Smalley**
PAST CHAIR	**Gautier Mathys**
BOARD	**Daniel Holdsworth**
	Viktor Khalack
	Oleg Kochukhov
	Jiri Krticka
	Ernst Paunzen

TRIENNIAL REPORT 2021-2024

1. Introduction

The purpose of the Working Group on Ap and Related Stars (ApWG) is to promote and facilitate research into stars in the spectral type range from mid-B to early F that exhibit surface chemical peculiarities and related phenomena. To facilitate this, the ApWG publishes a newsletter and distributes it to its members and ApWG members actively contribute to the organization of international scientific projects and meetings. The Ap and Related Stars community represents an active field of research, which takes full advantage of the new opportunities opened by the unprecedented data delivered by the space- and ground-based instruments that came into operations in recent years. Some of the resulting scientific highlights are presented in this report.

2. Scientific Highlights

During current triennium, over 200 research papers have been published by members of the ApWG. Here we present only a short selection of some of the scientific highlights.

The Ap and related stars community has continued to exploit the results of large surveys, especially that from the Transiting Exoplanet Survey Satellite (TESS) satellite. Holdsworth et al.(2021,2024) utilised TESS data to search for high-frequency pulsations in stars with effective temperatures greater than 6000 K with the aim of identifying and studying new members of the rapidly oscillating Ap (roAp) stars. The opportunities presented by TESS allowed for an almost unbiased search for class members like never before. They discovered 19 new class members and these works presented a homogeneous data set for statistical studies of the 112 known roAp stars, as observed by TESS. Also, exploiting the high-precision and high-cadence of TESS, Kochukhov et al. (2021) presented photometric data of 64 Mercury-Manganese (HgMn) stars and determined the incidence of rotational modulation and pulsations among HgMn stars. About 84% of the targets showed rotational variability with amplitudes of 0.1–3 m mag, indicating that presence of spots on HgMn-star surfaces is ubiquitous. Labadie-Bartz et al. (2023) presented a study of the photometric variability of a large sample of magnetic chemically peculiar stars discovered in LAMOST spectra. Using TESS data, the authors determined rotational periods of stars, which are suitable for further population studies. This paper showed that more evolved stars had longer rotation periods in agreement with the conservation of angular momentum during their evolution.

Members of the committee participated in the preparation of observations of chemically peculiar stars using the QUVIK (Quick Ultra-Violet Kilonovae surveyor) space telescope (Werner et al. 2022) and explored the possibility to use chemically peculiar stars to test the telescope.

Takahashi & Langer (2021) introduced a new approach to modelling of stellar evolution where the interplay between magnetic field, rotation, mass loss, and evolutionary changes of the internal structure of stars is treated self-consistently. The Lorentz force produces torsional Alfvén waves propagating through the star, which impose near-rigid rotation within the Alfvén timescale. Models with different initial rotational velocities and magnetic fields can reproduce the main observed properties of Ap/Bp stars.

Leto et al. (2021) presented the analysis of incoherent non-thermal radio emission from a sample of early-B to early-A magnetic stars. The paper challenged a well-established scenario in which the electrons producing the radio emission originate in current sheets formed in the outer magnetospheric regions where the wind opens the magnetic field lines. The paper discussed more realistic models of the radio emission, suggesting a scaling relationship between the radio luminosity and the induced electric voltage; valid for a diverse group of stellar types including magnetic main-sequence stars and ultracool dwarf stars and even the planet Jupiter.

Keszthelyi et al. (2022) published a systematic study of the effects of the magnetic fields on the stellar structure and evolution and provided grids of evolutionary tracks at three different metallicities. The magnetic fields influence the surface abundances via modified mixing and rotational velocities due to magnetic braking.

A paper by Owocki et al. (2022) studied the effect of centrifugal breakout as a mechanism of acceleration of electrons that power the radio emission of magnetic stars. The derived theoretical scaling matches well the empirical trends of observed radio luminosities of magnetic stars.

Mathys et al. (2023) reported the results for HD213258 which has a very long stellar rotation period of 50 years, derived from the analysis of the mean longitudinal magnetic field values measured using ESPaDOnS spectra and those found in previous publications. They confirmed that HD213258 is a roAp star with the pulsation periods found to be around 7.58 minutes. The mean radial velocity of this object is extremely high and shows low amplitude variations. This means that the star is a single-line spectroscopic binary with most probably a brown dwarf as the secondary. It is known to be an astrometric binary as well. Considering the aforementioned properties, HD213258 is one of the most interesting candidates for detailed study of extremely slow rotation and abundance peculiarities in Ap stars.

Members of the ApWG have continued a series of detailed studies of the surface structure of magnetic chemically peculiar stars using techniques of Doppler and Zeeman-Doppler imaging. These methods allow one to reconstruct surface maps of chemical spots and magnetic field vector from high-resolution time series spectropolarimetric observations. Among targets recently studied by Kochukhov et al. (2022) was the bright Ap star ϕ Dra, which was also observed by TESS nearly continuously for one year. Analysis of the space photometry (light time travel effect) and ground-based spectroscopy (radial velocities) revealed ϕ Dra to be a long-period single-lined spectroscopic binary. Its chemical maps showed an enhancement of Cr, Fe and Si in a series of spots encircling intersections of the magnetic and rotational equators. Another recent ZDI study of the star 45 Her (Kochukhov et al. 2023) mapped one of the weakest surface magnetic fields known in an Ap star. Despite sub-100 G average field strength, this star features well-developed surface chemical inhomogeneities with contrasts of several dex. The existence of such weak magnetic field is at odds with the predictions of field (in)stability by several theoretical studies.

Abundance studies of Ap and related stars continue at pace with many publications appearing during the triennium. For example, Monier et al. (2023) presented the results for six hitherto normal B-type stars, finding that they all exhibit chemically peculiarities! Similarly, Romanovskaya et al. (2023) published the results of a non-LTE analysis of some slowly rotating A and B stars. The diversity of their results challenges our current understanding of the mechanisms that give rise to abundance peculiarity in stellar atmospheres. They concluded with some questions, including "Are there normal A-type stars with solar abundances?"

The LAMOST low-resolution survey continues to provide a valuable source of new chemically peculiar stars for the community to explore; with Tian et al. (2023) producing a catalogue of over 20 000 Am candidates and Shi et al. (2023) over 2700 Ap stars. A spectral atlas based on low-resolution spectra from LAMOST has been compiled by Stefan Hümmerich. It covers the chemically peculiar stars of the upper main sequence, including the Am, Ap, HgMn, He-peculiar and λ Bootis stars. The atlas can be accessed from Richard Gray's MKCLASS website (`http://www.appstate.edu/~grayro/mkclass/`).

Paunzen & Prišegen (2022) investigated the detection of magnetic chemically peculiar stars using Gaia BP/RP spectra. They employed the well-established Δa photometric method to trace the 520 nm flux depression. They detected known magnetic chemically peculiar A and B stars with a 95% success rate. This nicely demonstrates that Gaia BP/RP spectra are suitable to search for new chemically peculiar stars.

Working Group Members Swetlana Hubrig and Markus Schöller published a book on *Magnetic Fields in O, B, and A Stars* (Hubrig & Schöller 2021). The book gives a comprehensive review of recent achievements in the measurements of stellar magnetic fields in O, B, and A stars, including those in chemically peculiar stars and an overview of the underlying physics for the interpretation of measurements.

3. A peculiar Newsletter

A peculiar Newsletter (ApN), the electronic newsletter of the ApWG, is the product of this group that is most valued by its members. Its contents include lists of recent publications in the field of Ap and related stars and announcements of interest for the scientific community working in that field (including conference announcements, job ads, and obituaries). It also serves as a forum for discussions among members of this community. In summary, since its foundation in 1978 (on paper, at the time), it has been an essential channel of communication and of reference for the scientists interested in Ap and related stars. The ApN is hosted on a server at the Leibniz Institute for Astrophysics Potsdam (`https://apn.aip.de/`), under the lead of the Editor, Dr Silva Järvinen.

4. Scientific meetings

At the beginning of the triennium, the COVID-19 pandemic severely curtailed scientific meetings, with many cancelled or postponed. Others migrated to an online format, such as *OBA Stars: Variability and Magnetic Fields* in April 2021 organized by several members of the ApWG. Topics covered by the online conference included, the origin of magnetic fields in convective and non-convective stars, methods of magnetic field measurements, stars with strong and weak magnetic fields, magnetic fields in Herbig Ae/Be stars, the results from large surveys and recent and current space missions, atomic and molecular data for stellar physics, and observations versus theory. Online presentations can be found at https://zenodo.org/communities/stars-2021/.

In October 2022, members of the ApWG organised an on-line meeting of the Eastern Association for Stellar Astrophysics (EASA), where chemically peculiar stars were discussed in many presentations. The next, in-person, meeting was in April 2023 at the Mt. Allison University, Canada. The 3rd meeting is planned for May 2024 in Moncton, Canada. Participants will have an opportunity to present their results in-person and on-line.

Members of the ApWG organized scientific meetings at the European Astronomical Society's 2023 meeting in Kraków, Poland; Symposium S5 *From stellar variability to stellar structure and evolution* and Special Session SS21 *Unveiling the secrets of chemically peculiar stars*. Several members of the board were involved with the organisation of the Special Session at the EAS 2023 meeting. We heard from 18 speakers on aspects ranging from binarity of chemically peculiar stars, to pulsations, and chemical abundance signatures and analysis. The Special Session ran on the first day of the meeting and was attended by some 50 or more participants.

There also continues to be regular meetings of the MOBSTER (Magnetic OB[A] Stars with TESS: probing their Evolutionary and Rotational properties) Collaboration (https://mobster-collab.com/) who are using TESS photometry and ground-based facilities to improve our understanding of magnetic stars.

5. Closing remarks

The Ap and Related Stars community has immensely benefited from the photometry obtained from exoplanet space missions, such as TESS, and the availability of the results from other surveys (e.g. LAMOST, GAIA). Going forward, this is set to continue as more results from surveys appear and new ground and space-based facilities become available.

It has, however, become increasingly clear to us that the heavily used Renson Catalogue of chemically peculiar stars (Renson & Manfroid 2009) contains many erroneous entries that serve to pollute attempts at collecting homogeneous samples of chemically peculiar stars. There are instances where stars are misclassified, where original references are missing, or it is very unclear where the classifications originated. This is leading us to extend effort to observe/analyse stars that fall out of the boundaries of a given project.

Therefore, members of the ApWG have started an ambitious long-term campaign to observe all stars in the Renson Catalogue with the High Resolution Spectrograph (HRS) on the Southern African Large Telescope (SALT). We aim, over several years, to collect spectra of the around 4400 stars observable by SALT in the medium resolution mode (R$\sim$40000) to build a publicly accessible database of spectra and stellar parameters. To date around 100 stars have been observed.

In this context, both the ApWG and ApN will be more crucial than ever. Their primary responsibilities include maintaining a steady flow of information among community members working on Ap and Related Stars, ensuring optimal access to pertinent information for their research projects and providing platforms for exchanging ideas and results. In short, the Working Group on Ap and Related Stars facilitates scientific research in this active field. We firmly believe that its ongoing operation is not only highly desirable but also highly beneficial.

Barry Smalley
chair of Working Group

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