LINK TO THE PHYSICAL MODELLING WITH AN EMPHASIS ON CHEMICAL PECULIARITIES

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Frequently, the atmospheres of stars of spectral types B to F, on which the attention is particularly focussed in this Joint Discussion, are characterized by non-standard physical conditions: non-solar abundance patterns, surface inhomogeneities, strong magnetic fields. The most extreme anomalies are found in the chemically peculiar (CP) stars but more moderate departures from standard atmospheres are observed in many stars in the considered temperature range. This can affect the derivation of fundamental stellar parameters in a number of ways, some of which will be presented in this contribution. The emphasis is set on those physical processes which are specific to CP stars. Due to lack of space, this review is necessarily incomplete: a selection of recent results of interest will be pointed out and some directions of investigation will be suggested.

CP stars have an anomalous continuous energy distribution. Fitting this distribution by standard model atmospheres can only be achieved using models corresponding to different effective temperatures to represent different spectral ranges (e.g., Leone & Catalano 1991). This is obviously not physically meaningful: the effective temperature characterizes the total flux of a star, thus is unique. "Realistic" models must incorporate the anomalous elemental abundances. Such models are presently being developed by Kurucz (ATLAS12) and by the Vienna group (Weiss 1994, private communication). The latter is adapted from Muthsam's (1979) code. One important result obtained by Muthsam is that the relation $T(\tau)$ appears steeper in magnetic Ap stars than in normal stars. This view recently received support from observations of rapid oscillations (Matthews et al. 1990). But even such realistic models may not represent satisfactorily CP star atmospheres, as some potentially important opacity sources may still be unknown. For instance, the broad continuum depressions observed in many magnetic CP stars have not been fully explained yet. Fe I makes an important contri-

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bution to many continuous features (Monier & Mégessier 1992) but some other ions must play a significant role too.

On the other hand, Ap stars have normal IR flux distributions (Kroll 1987). Therefore, the method of Shallis & Blackwell (1979) is well suited to the determination of their effective temperatures, as well as of those of the Am and HgMn stars. However, for the latter, which often belong to binaries, a modified version of the method must be applied (Smalley 1993).

The surface inhomogeneities of magnetic Ap stars (and possibly also of HgMn stars — Hubrig & Mathys 1994, in preparation) are an additional source of complication. In fact, the bolometric flux is the same everywhere, but the wavelength distribution of the emergent flux varies across the stellar surface, as a result of the non-uniform distribution of the elemental abundances, thus of the photospheric opacities. Accordingly, the atmospheric structure differs from place to place, and one should ideally compute different model atmospheres for a grid of points covering the star and derive the emergent flux by numerical integration.

In addition, increasing evidence for the existence of very significant abundance gradients of some elements in the photospheric layers has accumulated in the last few years (Babel & Lanz 1992; Smith 1994). Such stratification, if definitely established, will require an in-depth revision of model atmospheres, as all of them until now use a single abundance value for each element.

Temperature and surface gravity determinations in stars of the considered spectral types often rely on the observation of the profiles of the Balmer lines of hydrogen. With regard to this, one may be concerned by the possible variability of those line profiles. Such variations have been reported by several authors. However, these reports have been questioned: it has been argued that the claimed variability was actually a spurious observational effect. In any case, hydrogen lines are unlikely to vary as a result of an inhomogeneous abundance distribution (as H is much more abundant than any other element). But variations related to differences in the local atmospheric structure and/or due to the effect of a magnetic field might plausibly be observable.

The role of magnetic fields in the formation of hydrogen lines is in fact very poorly known. The difficulty comes from the fact that the Stark effect due to the motion of the hydrogen atoms in a magnetic field of kG order is of the same order as that due to the surrounding charged particles (see Mathys 1989 for more details). However, their combined effect has never been properly studied. Thus the derivation of fundamental parameters of magnetic CP stars from the consideration of the hydrogen Balmer line profiles performed until now are probably affected by unrecognized systematic errors.

On the other hand, magnetohydrodynamic effects may plausibly affect the very structure of the atmosphere of magnetic stars. The possible contribution of the Lorentz forces has been debated by various authors. One of the most recent studies is that of Landstreet (1987), which shows that such forces due to the decay of the fossil stellar magnetic field are likely insignificant in slowly rotating Ap stars. But for stars with rotation periods shorter than about 4 days, meridional circulation might have a non-negligible effect.

The determination of the projected equatorial velocity $v \sin i$ is also affected by the presence of a magnetic field, through the Zeeman broadening of the spectral lines. This has been known for a long time, and authors familiar with Ap stars have been careful to avoid this pitfall. Abundance inhomogeneities also show through in the line profiles and must be properly taken into account in $v \sin i$ determinations. But they provide a handle to a more direct measurement of the stellar rotation, as they are responsible for observable variations, from which the stellar rotation period (or the angular velocity) can be directly derived. For the stars for which both the period and $v \sin i$ are known, $R \sin i$ can be obtained: that is, another fundamental parameter, the stellar radius R, can be constrained. Even if the inclination of the rotation axis to the line of sight is unknown, this information can be exploited in a statistical manner. For instance, this approach was followed by Stepién (1989) to show that the radii of magnetic Ap stars were consistent with most of these stars being main sequence objects.

In view of the complexity and of the uncertainties of the photospheric physics of CP stars, any possibility to determine the fundamental parameters of these stars which does not rely on model atmospheres should be exploited — if only as a test of the adequacy of such models. This topic is however outside the scope of the present review.

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M. SMITH to DRAVINS Q. In the same spirit as your remarks, I shall also emphasize the role of velocity CORRELATIONS in producing sometimes dramatic (and often unintinted) effects on photospheric line profiles. Some exemples of which you have touched on are the ENHENCEMENT by rotation of line profile asymmetries initially produced by a granulation flows on a star and also the line profile bumps produced by a conspiracy of velocity fields correlated across the stellar disk caused by travelling equatorial waves (nonradial pulsations) and rotation. In such cases the wavelength shift of the profile is the result of a velocity vector addition, and it is this happy circumstance that has turned line profile fitting into its current cottage industry status. I would also make the obvious point that any high SNR "snapshots" of profiles should be distributed over time in order to find out whether some new features are/are not caused by time dependent mechanisms.
A. Yes, the study of line asymmetries caused by e.g. stellar surface convection (granulation) and modified by rotational broadening offers a possibility to study BOTH stellar surface properties AND stellar rotation. Whenever possible, observations should be repeated at differents epochs, especially if one aims for non-standard interpretation of the data.

G. PETERS to DRAVINS (Comment) I would exercise caution in assuming the validity of gravity darkening effects for the determination of a fundamental parameter such as Veq. Although the prediction of van Zippel theorem may be an aim theoretical grounds the existence of gravity darkening has <u>never</u> been observationally confirmed. Since Veq/Vcr is most likely about 50 % for B stars (a few Be stars may be rotating as much as 80 % of critical) the effects of gravity darkening, even in the most extreme scenario are probably <u>very</u> small.

(continued after the paper by Mermilliod)