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Spots on the surface of HgMn stars: clues to the origin of Hg and Mn peculiarities

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Abstract. The important result achieved in our recent study of a large sample of HgMn stars using UVES at the VLT and FEROS at the ESO 2.2 m telescope is the finding that most HgMn stars exhibit spectral variability of various chemical elements, proving that the presence of an inhomogeneous distribution on the surface of these stars is a rather common characteristic and not a rare phenomenon.

Key words: stars: abundances – stars: chemically peculiar – stars: magnetic fields – stars: differential rotation

1. Inhomogeneous chemical abundance distribution and magnetic fields

The fact that many late B-type SB systems contain a HgMn star as a primary points out that it is very likely that most normal late B-type stars formed in close binary systems are HgMn stars (Hubrig, Mathys 1996). From a survey of HgMn stars in close SBs, Hubrig and Mathys (1995) suggested that some chemical elements might be inhomogeneously distributed on the surface, with, in particular, preferential concentration of Mn around the rotation poles and of Hg along the equator. In a recent study of the star AR Aur which is the only known eclipsing binary with a HgMn primary we concluded that certain elements are very likely concentrated in a fractured ring along the rotational equator (Hubrig *et al.*, 2006 a). Also our recent survey of a large sample of HgMn stars using UVES at the VLT and FEROS at the ESO 2.2 m telescope to search for spectral variability caused by an inhomogeneous distribution of various elements on the surface of these stars revealed that most HgMn stars exhibit spectral variability of various chemical elements (González *et al.*, 2007, in preparation). Typically, inhomogeneous chemical abundance distributions are observed only on the surface of magnetic chemically peculiar stars with large-scale organized magnetic fields. Weak magnetic fields in the atmospheres of HgMn stars have been detected by Mathys and Hubrig (1995), Hubrig and Castelli (2001), and more recently by Hubrig *et al.* (2006 b). However, the structure of the measured field in HgMn stars is expected to be sufficiently tangled so that it does not produce a strong net observable circular polarization signature.

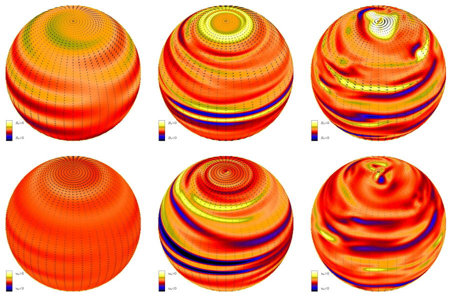

Figure 1. Radial magnetic field (upper row) and velocity (lower row) on the surface of a radiative star during the onset of the MRI (with steps of roughly 20 Myr).

2. Discussion

The role that magnetic fields possibly play in the development of anomalies in binary systems, has never been critically tested by astrophysical dynamos. Hubrig (1998) suggested that the tidal torque varying with depth and latitude in a star induces differential rotation. Differential rotation in a radiative star can, however, be prone to magneto-rotational instability (MRI) (e.g., Arlt *et al.*, 2003). Recent magnetohydrodynamical simulations revealed a distinct structure for the magnetic field topology similar to the fractured elemental rings observed on the surface of HgMn stars (Fig. 1). Complex surface patterns can be obtained from the nonlinear, non-axisymmetric evolution of the MRI. The combination of differential rotation and a poloidal magnetic field was studied numerically by the spherical MHD code of Hollerbach (2000). The initial model differential rotation was hydrodynamically stable (Taylor-Proudman flow), but the introduction of a magnetic field excites the MRI. The flows and fields resulting from the instability efficiently redistribute angular momentum and deliver a uniformly rotating star after about 10-100 Myr. The presented typical patterns of the velocity and the magnetic field on the surface of the star may as well be an indication for element redistribution on (or in) the star.

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