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MAGNETIC FIELDS IN SDB AND SDO STARS

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Abstract. We have started a survey of magnetic fields in hot subdwarfs, and here present our current results. The survey was inspired by the discovery of two super-metal-rich sdB stars, which lead to the idea that a correlation may exist between metal abundances and magnetic field strength, similar to that seen in the chemically peculiar A stars. After our initial observations, we find no clear correlation. We will discuss the possible meaning of these results and the implication of our detections for magnetic flux conservation in late stages of stellar evolution.

Key words: stars: magnetic fields – hot subdwarfs

This contribution contains only an expanded discussion of the implications of the detection of 1 kG magnetic fields in hot subdwarf stars. For full details of the observations and analysis of this work, see O'Toole et al. (2005).

In this initial study we have found no clear evidence that the extreme abundances seen in UVO 0512–08 and PG 0909+276 are related to a strong magnetic field. Our other observations of white dwarfs (Aznar-Cuadrado et al. 2004) and central stars of planetary nebulae (Jordan et al. 2005) using the same instrumental setup and reduction procedure have measured similar fields with strengths ranging from -3 kG to +4 kG.

The detection of kilogauss strength magnetic fields raises questions for several areas of hot subdwarf research. Detailed analysis of these is beyond the scope of this work, however we present a qualitative discussion here.

First of all, how are the fields generated? The Sun's magnetic field is believed to be dynamo-induced; that is, the solar core is rotating at a different speed with respect to the outer layers. Fields in magnetic white dwarfs (and magnetic Ap stars) are thought to be fossil fields. A link has been suggested between these two types of stars, and this would necessarily mean that their magnetic fields are tied to the stellar core, since even a weak stellar wind would destroy fields only existing in the outer layers. In the case of the hot subdwarfs, no firm evidence exists for differential internal rotation, although it has been proposed by Kawaler & Hostler (2005); this implies that dynamo-induced fields are unlikely. The case of fossil fields is less clear. If the fields are leftover from, for example, the star formation cloud, then we might expect the fields to evolve with the star. It is unclear how binary evolution (CPD −64 481 probably has passed through a common envelope phase) might affect the magnetic field of the star's progenitor.

Second, what implications, if any, do these results have for any assumptions of conservation of magnetic flux in stars? This is difficult to answer as there is yet no consistent theory that includes magnetic fields, convection, rotation, diffusion and winds in stellar evolution. From an empirical standpoint, however, if magnetic flux is completely conserved in sdB stars, then, based on our measurements, we would expect a population of low-mass white dwarfs with magnetic field strengths of up to ∼500 kG. The observational statistics is too low at the moment to conclude which way is right.

Another question we might ask is: how would a magnetic field affect gravitational settling and radiative levitation calculations in hot subdwarfs? Naively we might expect such a field to disrupt diffusion, however, abundance anomalies with magnetic fields are also seen in chemically peculiar A stars and are in fact believed to play a role in the element enhancement. We therefore suggest that magnetic fields of around 1 kG should be included in sdB diffusion calculations, at least in a simple way.

Finally, it is well known that a small subset of sdBs pulsate. A magnetic field of ∼1 kG should have some effect on the pulsations, most obviously as a splitting of a single pulsation mode into a doublet. There are more interesting consequences if the pulsation modes are high-order, however. In the roAp stars, kilogauss-strength fields lead to a region in the stellar atmosphere where magnetic pressure dominates over radiation pressure. This will of course have an additional effect on the nature of the oscillations.

Because the questions outlined above, we feel urged to extend spectropolarimetric measurements to additional sdB and sdO stars. First of all, we lack a sample of "normal" sdBs, i.e. objects which neither pulsate, nor are members of close binary systems, nor have already evolved away from the EHB. Since the pulsating sdB stars are much fainter than the stars studied here, it will be much harder to get similarly accurate measurements of field strength for them. Nevertheless, we have been awarded additional observing time with FORS1 at the VLT to measure one pulsator and several "normal" sdB stars with the same setup.

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