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The magnetic field generated by sources inside and outside the star

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Abstract. The magnetically sensitive atmosphere of a star is an ideal detector of the magnetic field penetrating the atmospheric layer – regardless of whether the field source is inside or outside the star. Most magnetic stars possess their own magnetic field sources in their interiors, and one usually neglects the possibility of externally caused influences of magnetic fields. Only powerful interior or nearby magnetic sources may influence detectably the atmosphere of a star with a sufficiently large surface. An externally influenced magnetic field can be found in a binary system consisting of a non-magnetic giant with a magnetic dwarf companion.

Key words: stars: magnetic fields – methods: analytical – stars: individual: ν Cep

1. Sources and vortices

Since magnetic fields are bound to moving electrically charged particles, whose path of propagation is surrounded by circularly closed lines of force, real magnetic sources do not exist. A physically more suitable description of magnetic fields would be given by the vortex calculus. According to a theorem of potential theory, every stationary vector field may be described as the superposed fields emerging from sources and vortices. Both sources and vortices form – by suitable combination – dipoles with a magnetic moment as an axial vector. The superposition of the fields of a positive and a negative "magnetic charge" of equal quantities produces a magnetic dipole, which is analogous to an electrical dipole and is a physically reasonable model of a dipole. Such magnetic dipoles are used here as the elementary "bricks" of a space-filling composite magnetic field – both inside and outside the star.

Inside the star: The "magnetic charges" may be positioned anywhere in the interior of the star, forming a pattern of spatially distributed point sources. The charges are all members of dipole pairs, implying that the sum of all positive and negative charges is zero. By a suitable combination of dipoles any desired field structure may be constructed. The dipoles need not to be centered in the middle of the star. The normal case would presumably be one with deviation from central symmetry: in simplest approximation, the decentered dipole.

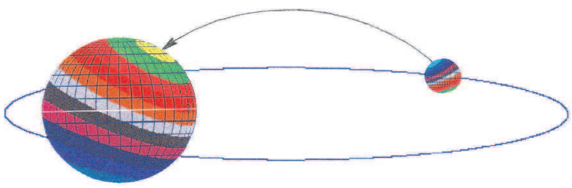
Outside the star: The magnetic field of a star becomes evident only at its surface, from which we can deduce the field structure in the surrounding space by extrapolation. Such a field can influence a body in the vicinity, for example an orbiting companion. Therefore, the reverse situation is also possible. Recall that we observe predominantly the star of the binary system which has the brighter luminosity, which could be the non-magnetic primary star. In the atmosphere of such a star we can expect to observe the following phenomena: **i)** The rotation periods of the star derived from $v \sin i$ and from the brightness variation do not agree; **ii)** The periods of the variations of radial velocity and effective magnetic field strength have a relation of 2:1; **iii)** In case of an elliptical orbit the phase curves are not equal, thus simulating a surface structure different from the true surface structure.

A number of further conclusions could be drawn, especially concerning other astronomical systems with mutual magnetic influence. Magnetic fields in the observed atmospheres are calculable under the assumption of magnetic sources outside the star.

2. The "magnetic" supergiant star ν Cep

Magnetic fields are commonly attributed as a property to a star itself. The possibility that the field comes from outside the star has not been considered yet.

In contrast to all expectations, the striking observation (made by G. Scholz in 1978) of a strong magnetic field of +2000 G in the supergiant A2Ia star ν Cep (HD 207260), which cannot retain an intrinsic magnetic field because of field-destroying processes such as convection (Gerth, 1988), could not be explained reasonably, and led to the assumption that we observe on this star the influence of the external magnetic field of a companion in a close binary system. Thus, this interesting object can be considered as a prototype of a star with an **indirect magnetic field** – as demonstrated schematically:



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