ι Cas: Multi-element Doppler imaging and magnetic field geometry

R. Kuschnig[1], G.A. Wade[2], G.M. Hill[3] and N. Piskunov[4]

[1] *Institut für Astronomie, Universität Wien, Türkenschanzstr. 17, A-1180 Vienna, Austria*

[2] *Physics & Astronomy Department, University of Western Ontario, London, Ontario, Canada, N6A 3K7*

[3] *McDonald Observatory, University of Texas at Austin, P.O. Box 1337, Fort Davis, Texas, USA 79734*

[4] *Uppsala Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden*

Abstract. In order to clarify the role of the magnetic field in generating abundance inhomogeneities in the atmospheres of Ap stars, we present new abundance Doppler images and an approximate magnetic field geometry for the Ap star ι Cas.

Key words: Stars: chemically peculiar – Stars: magnetic fields – Polarisation

1. Introduction

The inhomogeneous distributions of surface chemical abundance observed in the Ap and Bp stars are thought to result from a complex interplay between gravitational and radiative diffusion, mass loss, turbulence and circulation processes in their atmospheres (Michaud & Proffitt 1993). By determining the magnetic field geometries and surface chemical abundance distributions of a representative sample of these objects, important new contraints can be placed upon the manner and degree to which these processes interact with the magnetic field.

ι Cas (HD 15089) is classified as A5p in the *Henry Draper Catalogue.* Its projected rotational velocity is moderately high ($\sim$ 50 km s^{-1}), making it an ideal candidate for Doppler imaging. Borra & Landstreet (1980) obtained four Balmer-line magnetometer measurements of the longitudinal magnetic field of this star, with 1σ uncertainties around 150 G. All but one are consistent with zero field, indicating that the magnetic field is quite weak. The photometric period (which we assume to be the rotational period) has been previously reported by a number of authors.

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2. Observations

10 spectra of ι Cas were obtained at Observatoire de Haute-Provence using the AURÉLIE spectrograph, during 1994 and 1995. The spectral resolution of these data is about 2×10^4, and the SNR is about 200:1.

Ephemeris	$2437247.704 + 1.7405 \cdot \mathrm{E}$
$v \sin i$	48 $\mathrm{km\,s^{-1}}$
Inclination	50 deg
T_{eff}	8500 K
$\log g$	4.0

Table 1. Input data for the abundance Doppler images

15 measurements of the longitudinal field variation of ι Cas were obtained using the photoelectric polarimeter at The University of Western Ontario Elginfield Observatory. A detailed description of the instrument and the observing technique are given by Landstreet (1980).

3. Magnetic field geometry

The new magnetic field measurements, phased according to the ephemeris cited in Table 1, are shown in Fig. 1. The longitudinal field clearly undergoes a sinusoidal variation, indicative that the geometry of the photospheric magnetic field is predominantly dipolar. Assuming such a field configuration, and the rotational axis inclination assumed for the Doppler images (cited in Table 1), we compute the obliquity of the magnetic axis to the rotational axis $\beta = 70\,\mathrm{deg}$ and the polar field $B_{\mathrm{d}} = 1500$ G using the expressions of Preston (1967). According to this model, the magnetic poles are at rotational coordinates $(l, b)_+ = (195\,\mathrm{deg}, +20\,\mathrm{deg})$ and $(l, b)_- = (15\,\mathrm{deg}, -20\,\mathrm{deg})$.

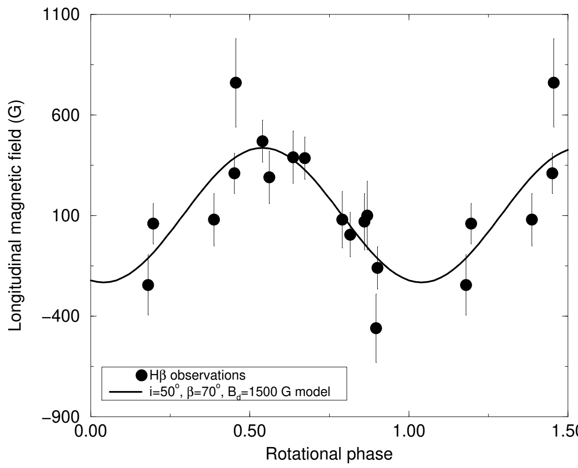

Figure 1. Longitudinal magnetic field variation of i Cas.

4. Doppler Images

Abundance Doppler images of ι Cas were obtained using the INVERS8 Doppler imaging code (Piskunov & Rice 1993). In Fig. 2 we show Cr abundance distribution maps (in rectangular and spherical projection) and line profile fits computed for the line Cr II λ4558.65. Maps of the Fe, Mg and Ti distributions show similar structure.

The mean Cr abundance of ι Cas is enhanced by about 1 dex above solar. A clear ring of enhanced abundance is apparent in the northern hemisphere. The coordinates of the northern (positive) magnetic pole as derived above place it within the enhanced ring. The southern (negative) pole does not appear to be associated with any obvious abundance feature. This scenario is similar to that observed for HD 153882, in which Fe appears to be distributed in an enhanced (broken) ring, with the northern magnetic pole located within the ring (Ryabchikova et al. 1995).

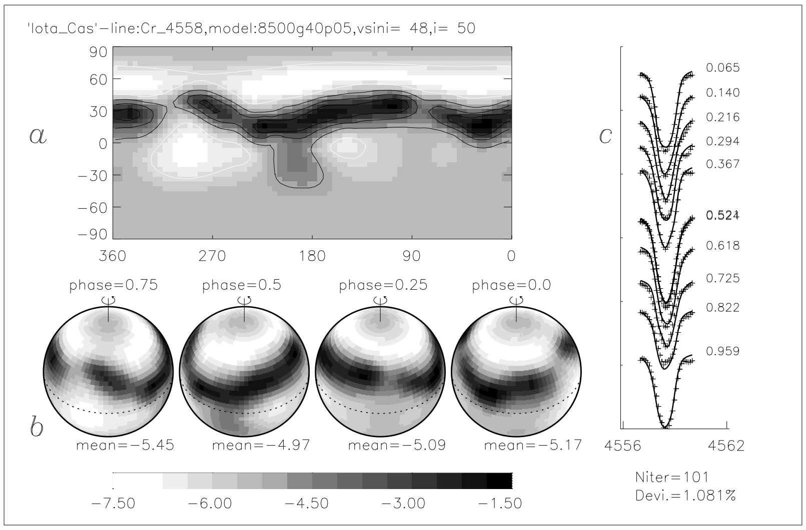

Figure 2. Cr abundance distribution of i Cas.

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