STARSPOT IMAGING USING VRI PHOTOMETRY

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ABSTRACT. Recent progress on maximum-entropy imaging of stellar surface brightness distributions using VRI photometry and Doppler-broadened absorption line profiles is reported. VRI photometry generally provides tighter constraints on starspot configurations than does Doppler imaging (which requires the use of large telescopes). Observers carrying out long-term photometric monitoring programmes on spotted stars are urged to work in the VRI system, as well as the UBV.

1. INTRODUCTION

The RS CVn and related late-type active chromosphere stars have attracted much well-deserved attention from photometrists in recent years and - judging from the number of groups at this conference who are actively engaged in long-term monitoring programmes - will continue to do so. Such programmes will ultimately yield important information concerning the evolution of individual stellar active regions, surface differential rotation and activity cycles in stars with a wide range of rotation rates and envelope structures. However, it is important to consider at the outset just what type of observation should be made in order to maximise the scientific return, in the light of recent developments in the interpretation of such data, which are described here.

2. IMAGE RECONSTRUCTION METHODS

The most difficult problem to be surmounted in the interpretation of RS CVn light-curve observations is that of uniqueness. Generally, any number of stellar surface brightness distributions can be devised which for a given axial inclination (often unknown a priori) can reproduce the observed V light-curve.

Vogt (1981) introduced an important refinement which used the colour-surface brightness relations of Barnes, Evans and Moffett (1978) to resolve the ambiguity between the temperature of the starspots and their total covering fraction on the visible stellar disk at each

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rotation phase. The success of this method relies on the availability of VRI photometry, as line-blanketing in the U and B bands causes the colour-surface brightness relations at the blue end of the spectrum to break down at the temperatures typical of starspots.

The application of the maximum entropy method to the reconstruction of stellar surface brightness distributions from VRI photometry and/or Doppler imaging (Vogt and Penrod 1983) has been described by Cameron and Horne (1986). This technique involves the setting-up of a transformation from a two-dimensional image of the stellar surface to a data set consisting of flux observations in a number of different wavelength bands at different phases throughout the rotation cycle. The image is then adjusted iteratively using the maximum-entropy algorithm of Skilling and Bryan (1984) to yield that image which minimises the amount of configurational information in the starspot distribution on the image, subject to the constraint that it must reproduce the observed data at a satisfactory level of the χ^2 statistic.

Our early studies with both synthetic and real data (Cameron et al 1986) indicate that it is feasible to reconstruct stellar images from VRI photometry, provided that (1) complete phase coverage is available; (2) internal errors on individual data points are less than 10% of the total amplitude of variation; and (3) the inclination of the rotation axis to the line of sight is less than 70° or so. At higher inclinations, the lightcurve contains little information to constrain the spot latitude. At lower inclinations, artificial elongations of the spots in either the latitudinal or longitudinal direction occur if a reconstruction is attempted at the wrong inclination; given data of sufficiently high quality, the axial inclination may be determined to within about 10° from the lightcurve alone.

3. FUTURE WORK

Perceptible changes in lightcurve morphology in the RS CVn and related systems have been observed to occur on timescales of weeks to months. Some of these changes appear to be caused by shifts in the relative positions of spots at different latitudes through differential rotation, others by the growth and decay of entire active regions. Image reconstruction methods of the type described here provide a powerful tool for the analysis of these processes on spotted stars, provided that high-quality lightcurves in the VRI system can be obtained at regular intervals for the systems under study.

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