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Photometric Imaging with Distributive Solar Analogy

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Abstract

The importance of DSA (Distributive Solar Analogy) when modeling starspots from a photometric data is discussed. It's advantage over the other modeling techniques to confine the solution parameters, especially the spot latitudes are described. Unlike the other photometric techniques which tries to locate limited number of cool surface spots, DSA aims to model global distribution of all virtually existing spots.

1. Introduction

According to analytical investigations of Eker [1, 2, 3], the starspot hypothesis is a consistent physical problem. However, accuracy of the current earth-based photometric data is insufficient for a successful imaging. From the propagated uncertainties of various test models, it is predicted that [3] that minimum ∓ 0.0001 mag or a better accuracy in the observed curves is needed for a successful modeling. Among the other derived parameters, spot latitudes are the most uncertain with an amount bigger than physically meaningful limits. Even for the models with known i (inclination of rotation axis), the uncertainty of latitudes are greater than 90 degrees if photometric accuracy is about ∓ 0.005 mag which is considered the best achievable accuracy on the earth today.

Therefore all the troubles and failures for determining spot latitudes, latitude fixing and related non-uniqueness ambiguities can be attributed to the insufficient accuracy. These facts are already included in the conclusions of previous talk in this meeting. This study aims to explain powerfull advantage of Distributive Solar Analogy (DSA) over other starspot modeling thechniques to confine the solution parameters.

2. Discussion

Living in today's accuracy limits, which do not allow classical modeling techniques to locate spots on the latitude scale, additional constraints are needed to confine solution

parameters, especially latitudes into unique values. Thus, DSA stands out to provide logical arguments to set up the entropy conditions to provide such a confinement.

DSA was introduced by [1] and improved by [4]. The original motivation was to develop a new modeling technique which is inspired by the solar analogy. Starspots were already accepted or believed as a solar analogy because of sunspots. If sunspots exist why not starspots?

But, an overview of the published models indicates that predicted spot distributions do not agree with the distribution characteristics of the sunspots. Originally, DSA was aiming to correct this problem. Therefore, following a priori assumptions were set by Eker [1, 4].

1. Spot distribution (total area or number) must be equal between the hemispheres which is divided by the equator.

2. Asymmetric light curves can be produced by uneven distribution of spots on the longitude axis.

3. The simplest model contains one spot reion on each hemishere to modulate the starlight. So, if these regions are named A and B

   - a) $r_A = r_B$ (sizes must be equal)
   - b) $\beta_A = -\beta_B$ (angular distances from the equator must be equal)
   - c) $\lambda_A \neq \lambda_B$(different longitudes can provide asymetric light curves).

4. Asymmetry (slightly different sizes and latitudes) within the solar analogy (like sunspots) is permitted because sunspots too do not have a full symmetry. More spots can be added if permitted asymmetry does not help to improve the fit.

5. If reducing light levels equally at every phase is necessary (This happens if unspotted magnitude is much above the maximum brightness of the light curve), polar or belt spots (numerous small spots evenly distributed on the longitude scale) can be used. Polar spots contain one polar spot on each pole contradicts the solar analogy because sun do not have polar spots, but at least keeps the symmetry between the hemispheres.

Those a priory assumptions are already applied to analyze the light curves of HD12545 [4] and HU Vir [5]. These applications are indeed succesful confining the solution parameters, especially the spot latitudes. Therefore, the solutions of the light curves of HD12545 and HU Vir are claimed to be unique [4, 5] in a sense that final fitting parameters are independent of initial trial values. That is, whatever the initial parameter were set to, the iterations would give a same fitting parameters at the end. It is possible to fall in a false minimum but it is correctable as described in these studies.

3. Conclusions

Especially after evaluating the propagated uncertanities of inverse photometric problem [3, 5, my previous paper in this proceeding], photometric imaging with DSA gained a crucial importantance. This is because the technique with DSA aims to determine global distribution of spots rather than locating few individual ones. Moreover, the photometric imaging with DSA not only restores the lost symmetry between the hemispheres but also helps to constrain the solution parameters especially latitudes which other modeling techniqies fail to constrain

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