VLA STEREOSCOPY OF SOLAR ACTIVE REGIONS

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Extended Abstract

We develop a new technique for extracting three-dimensional (3D) information from multi-day solar VLA observations. While standard stereoscopic methods provide a 3D view of an object by combining simultaneous observations from two different aspect angles, we relax the condition of simultaneity and exploit solar rotation to vary the aspect angle. The solar radio images are decomposed into Gaussian source components, which are then cross-correlated in maps from preceding and following days. This provides measurements of the 3D position of correlated source centroids.

Tests with simulated and real radio maps (from the VLA at 20 cm) demonstrate that (i) the information content of a VLA map relevant for stereoscopic correlation can be conveniently represented in terms of a small number of Gaussian components; (ii) the fitting of the three-dimensional source position is stable within a numeric accuracy of ≤ 0.02 map pixel, (iii) the relative accuracy of the altitude determination is uniform over the solar disk, and (iv) source confusion does not affect the accuracy of stereoscopic position measurements in $\approx 95\%$ of the cases.

We performed stereoscopic correlations between radio maps obtained on 6 different days in July/August 1989 and establish the presence of 66 radio source components associated with 22 active regions. We find the following statistical results for active region source structures at 20 cm:

(1) the observed lifetime is consistent with an exponential distribution with an e-folding time scale of > 18 days;

(2) the average altitude of 20 cm sources is 25 ± 15 Mm; 90% of the sources are found in heights < 40 Mm;

(3) the average diameter of discrete source structures is 48 ± 15 Mm, implying a vertical/horizontal aspect ratio of $q_A \approx 0.5$;

(4) no significant source motion has been found with respect to the standard differential rotation rate of $\Omega = 13.45° - 3° \cdot \sin^2 B$;

(5) we discovered a statistical limb darkening, which can be described by the relation $T_B(\alpha)/T_B(0) = 0.4 + 0.6 \cos^2 \alpha$ for sources with $T_B > 0.5$ MK;

(6) the degree of source polarization is $15\% \pm 10\%$ and is independent of source location;

(7) bright sources ($\gtrsim 0.5$ MK), or equivalently, long-lived sources ($\gtrsim 5$ days) show a systematic variation of their altitude as function of the center-limb distance.

We investigated a number of homogeneous and inhomogeneous active region models, and find that inhomogeneous (both temperature and density) models are required to reproduce all observational constraints. Details on the method and results are given in the papers by Aschwanden and Bastian (1994a,1994b).

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References

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