

ANALYSIS OF BROAD-BAND H α CORONAGRAPHIC OBSERVATIONS

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Abstract. Broad-band full-limb H-alpha images of the inner corona were obtained since the beginning of the solar cycle 23 using one of the Pic-du-Midi coronagraph. We developed a tool to process the complete set of stored images and to extract automatically the properties and evolutions of the observed cold HI coronal structures over a large range of sizes and light fluxes, from small jets and/or spikes to large prominences. The paper describes the recognition techniques implemented in our software and discusses its use. Then we present some new results following a statistical analysis of the occurrence of structure parameters applied to a large sample of observations. It illustrates the capabilities of this software when applied to our database. Strong activity-asymmetries over the solar poles are shown, confirming similar results from elsewhere. We also discuss the distribution of relative light fluxes of these structures over a wide range of sizes. See also: <http://bass2000.bagn.obs-mip.fr>.

1 Introduction

The 15 cm coronagraph of Pic-du-Midi Observatory (Niot and Noëns 1997) called "HACO" (H Alpha COro-nagraph), has been used to perform a daily survey of the evolution of the cool structures in the inner corona since 1994. Our full limb coronagraphic H α images are collected using a broad-band filter, with a time cadence which depends on the observed events. This program has provided a database of more than 185000 images covering the solar cycle XXIII. It was therefore necessary to build a special software in order to extract useful information about the HI structures and their time evolutions from this long time series. Here we describe briefly the software and the first results. More details can be found in Romeuf et al. (2006).

2 Data processing

We have developed a software, SCANPOTU, with the objective of providing calibrated images of the limb as well as a list of structures identified on the limb together with some of their properties. After flat-field correction and a photometric calibration which takes into account the filters and the variation of atmospheric transparency during the day, we perform the following steps :

- Find the disk centre and the solar radius in arbitrary units
- Transform into polar coordinates
- Compute the wavelet planes
- Suppress the artefacts and parasitic fringes created by the occulting disk
- Determine an average profile around the limb and filtering processing
- Perform a "pyramidal" analysis
- Compute a calibrated image
- Analyse the properties of each detected structure

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The properties of each structure for each detection (i.e. corresponding to each image) is included in a SQL archive (http://bass2000.bagn.obs-mip.fr/New2003/Pages/Coro/interro_scanprotu.html). The data can be retrieved in several ways. First, a simple form can be filled to provide the requested variables owing to various criteria (date, size, etc.). A large ascii file containing the list of structures and their properties can then be retrieved for subsequent analysis. Second, ready-to-use codes are also available. They use the database, make simple computations and provide results such as histograms, time evolution of structure location (coronagram), average value of a given parameter versus the polar angle, etc.

3 First results

A subset of data, covering 3 years, has been analysed using this technique. We have obtained several results concerning the relationship between the light fluxes F_s and effective surface S of structures, the distribution of these parameters, and the latitudinal distribution of the structures, including very small ones. Effective surfaces are evaluated as a fraction of $10^{-5} S_{\odot}$ (with S_{\odot} the surface of the solar disk). Three different regimes can be observed in the light fluxes and effective size distribution. Furthermore, the relationship between light fluxes and effective surfaces is found to be approximately linear on a log-log scale over almost three orders of magnitude. It corresponds to a power law with a slope of $5/4$. For larger structures the flux is smaller than expected from the linear fit. There are in fact two regimes in the linear domain, with two distinct slopes below an effective surface of 1 (slope of 1.108 ± 0.003) and above it (slope of 1.312 ± 0.001). The slope is in general larger than 1, showing that in the linear regime, larger structures have a larger flux per square pixel than smaller ones. The exception is for small structures, with a slope consistent with 1, indicating a constant flux per square pixel for S up to 1. Finally, we have studied the latitudinal distribution of structures for various categories of sizes. For all structures, we observe small gaps in activity at the equator and just above the activity belt, as well as a strong asymmetry between hemispheres, especially close to the poles. Very small features are definitely more present at the poles. The gap at intermediate latitudes could be related to the fact that it has been difficult to establish a connexion between the high latitude branch of solar activity (observed in the corona and using filaments as tracers) and the low latitude one (activity belt), as illustrated for example in Leroy & Noëns (1983). This is of great interest to the solar dynamo theories as it provides some constraints on the behavior of the dynamo waves. The North-South asymmetry may also be related to the dynamo action.

4 Conclusion

The software we have developed allows the detection of structures over a wide range of sizes, from small jets to large prominences. The preliminary results indicate interesting properties over this wide range of light fluxes, i.e. over almost eight orders of magnitude and over more than three orders of magnitude in effective surfaces. This database can therefore potentially be used to study in detail the parameters of small-scale structures, such as their spatial distribution in latitude, their lifetime distribution, as well as the variation of their properties over the solar activity cycle and the relationship with the closest active regions, eruptions, etc., taking into account the difference between the Northern and Southern hemisphere distributions. This software is currently being applied to the whole time series of HACO data (covering more than one solar cycle), as well as to the data from the new Pic du Midi Coronagraph, CLIMSO, which should start operating next spring. All the results will be available on the BASS2000 web site (<http://bass2000.bagn.obs-mip.fr>).

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References

- Leroy, J.-L. & Noëns, J.-C. 1983, *A&A*, L1
 Meunier, N., Lafon, M., Maeght, P., Girmaud, F., & Roudier, T. 2006, this volume
 Niot, J. M., & Noëns, J.-C. 1997, *Sol. Phys.*, 173, 53
 Romeuf, D., Meunier, N., Noëns, J.-C., Koutchmy, S., Jimenez, R., Wurmser, O., Rochain, S., and the "Observateurs Associés" Team, 2006, to appear in *A&A*