Journées SF2A session 13 « Collaboration Pro- Am. », 7 juin 2021

Polarimetric Coronagraphy to record the initiation of CMEs

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Abstract: Following important investment plans by the main Space Agencies for developing the Space Weather, the next decades will see the development of new facilities to support the observations of the dangerous for many Critical Economic and Space Systems Coronal Mass Ejections (CMEs) especially active during the Years of sunspot maximum. The important phase of the initiation process at the origin of CMEs is still mysterious: filament eruptions, prominence destabilization, rising coronal cavity inside the hot corona, flare induced explosions of active regions coronal enhancement, EUV wave, arch system interactions with subsequent magnetic reconnections, etc. are suggested. X- EUV space-borne instruments will provide coronal temperature sensitive images without direct measurements of coronal masses in the inner corona. It is then also appropriate for advanced Amateurs to take part in this routine research. It is proposed to use a new adapted coronagraph to perform this study in the frame of the association called "Observateurs Associés" of the Pic du Midi Observatory to collect data on the electron corona, over in field of view of 3 solar radii by recording polarized white- light images. This 2- parts instrument will take advantage of the excellent large equatorial mount already used by the "CLIMSO" cluster of coronagraphs that analyze the more inner corona. The instrumental parameters of this original coronagraph will be outlined and the first results of laboratory measurements performed using an artificial Sun will be discussed.

Edge diffraction visualized using a simple disk put at a distance of 6 m of the entrance pupil of an imager put on the equatorial mount of the Pic du Midi Observatory. Coronal sky where the Rayleigh component dominates but with « flying snow » .

Why an externally occulted coronagraph instead of the original Lyot design?

The large **chromatism** of a primary lens makes impossible the use of a **large spectral range; the shadowing of the entrance doublet lens is needed to considerably reduce (by 10^6) the level of the scattered light inside;**

The shadowing avoids the Heat in focal plane that adds internal turbulence; **it also avoids the variable diameter of the internal occulting disk(s);**

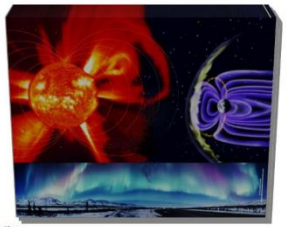
The variable vignetting provided by the External Occultation permits a compensation of the **radial gradient of the inner parts of the corona** (no very-near limb data available);

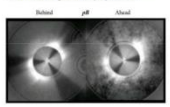
Spherical, field curvature and **astigmatism aberrations** that are difficult to compensate in case of a large field of view are reduced;

Reducing the polarization aberrations due to the **bi-refringency** inside the glass (temperature inhomogeneities, edge effects, stress) to achieve a **precision of 10^{-3} or better in linear polarization** over the whole field permits to reject the large un-polarized background;

Finally the use of the **new CMOS polarimetric fast camera** with 5 Kpxs covered with linear polarizers in 4 directions (0°, 45°, 90° and 135°) gives a large multiplexing (by **10^6**) compared to the 2 channels former Lyot- polarimeter of the K- coronagraphs.

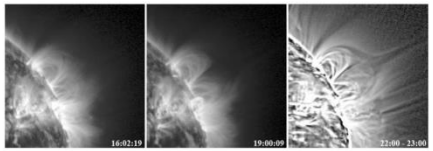
Cartoon from NASA to illustrate the context of the Sun- Earth links **through CMEs** with associated obvious effects like i/ the bow shock of the magnetosphere where reconnections can occur and ii/ the polar aurora.



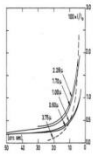


Map of pB (intensities showing the polarized brightnesses) observed after some processing; observations with the Space-borne COR-1 coronagraphs of the STEREO mission that use only an internal occultation still producing a large amount of parasitic instrumental scattered light in the background.

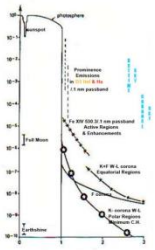
Map of pB (intensities in colors to show as well the directions of polarization observed during the solar total eclipse of 2019. Note the directions of p everywhere in tangential to the limb directions. (David Elmaore comm.)

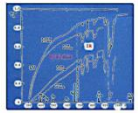


Example of a configuration possibly leading to a CME : Formation of a coronal cavity in a quadrupolar magnetic configuration beleived to give rise to a collimated EUV jet. Fe IX observations from SWAP (Proba 2) made in space. White light observations are needed to confirm the scenario. From a paper by Filippov, Koutchmy and Tavabi, 2011.



Most important for coronal research **background brightnesses of the solar aureola** (combination of the instrumental and the aerosols contributions), near the Sun **and typical coronal intensities of interest** using different large dynamic scales. Some typical values measured using different solar telescopes are shown inserted at the left. . At right, Earth spectral transmission for different typical sites on the Earth with the position of the main chromospheric lines shown at the bottom.





References

Koutchmy et al (1990) « Real- time image processing and data handling for ground-based and spaceborne coronal observations », Proc. SPIE 1235, Instrumenation in Astron. VII ; doi : 10.1117/12.19149

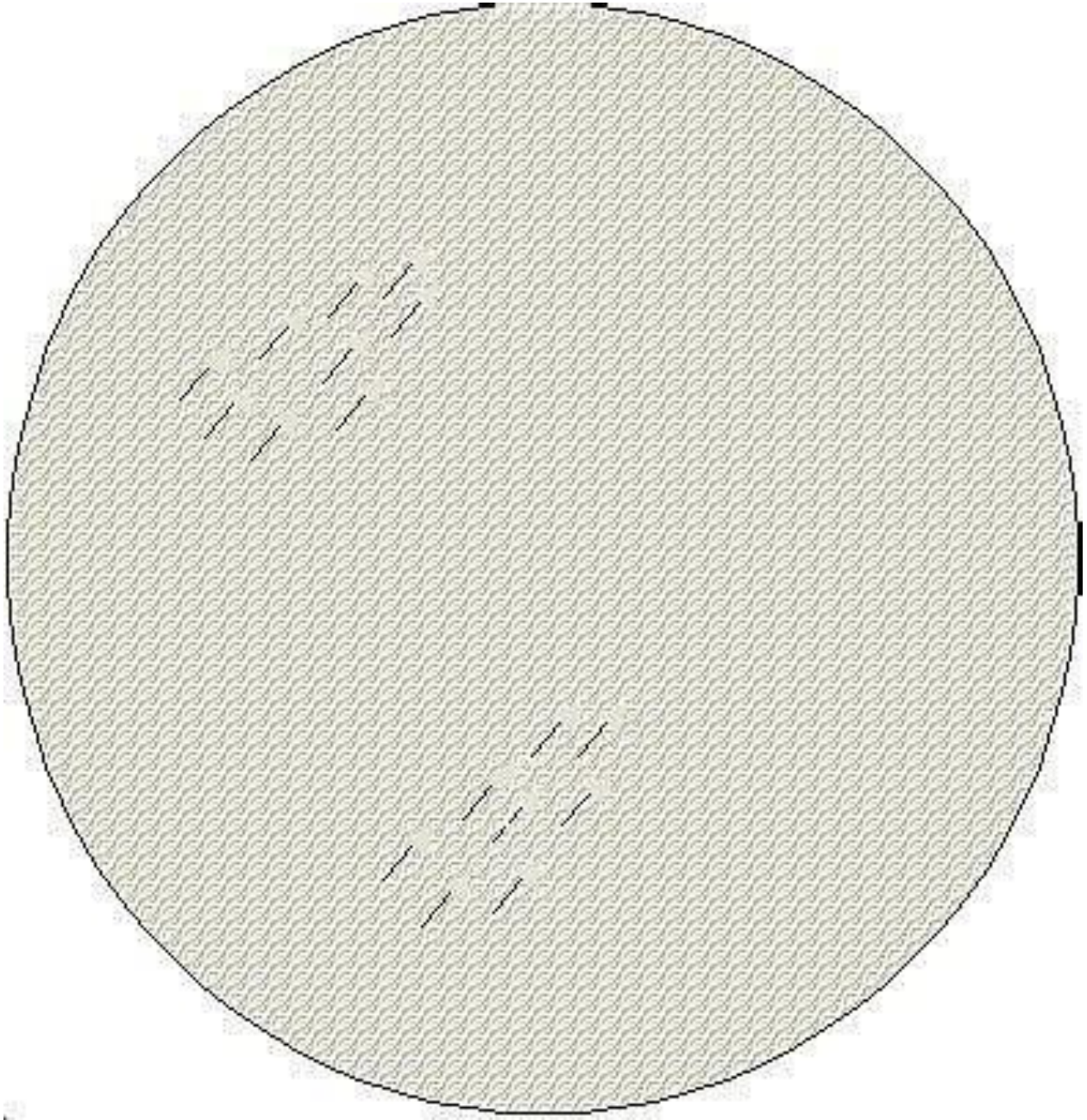
Koutchmy, S. Belmahdi, M. 1987, *J. Optics (Paris), vol. 18,* nos 5-6, pp. 265-269

Noëns J.C., Wurmser O., 2000, *Astrophysics and Space Science*, 273, 17

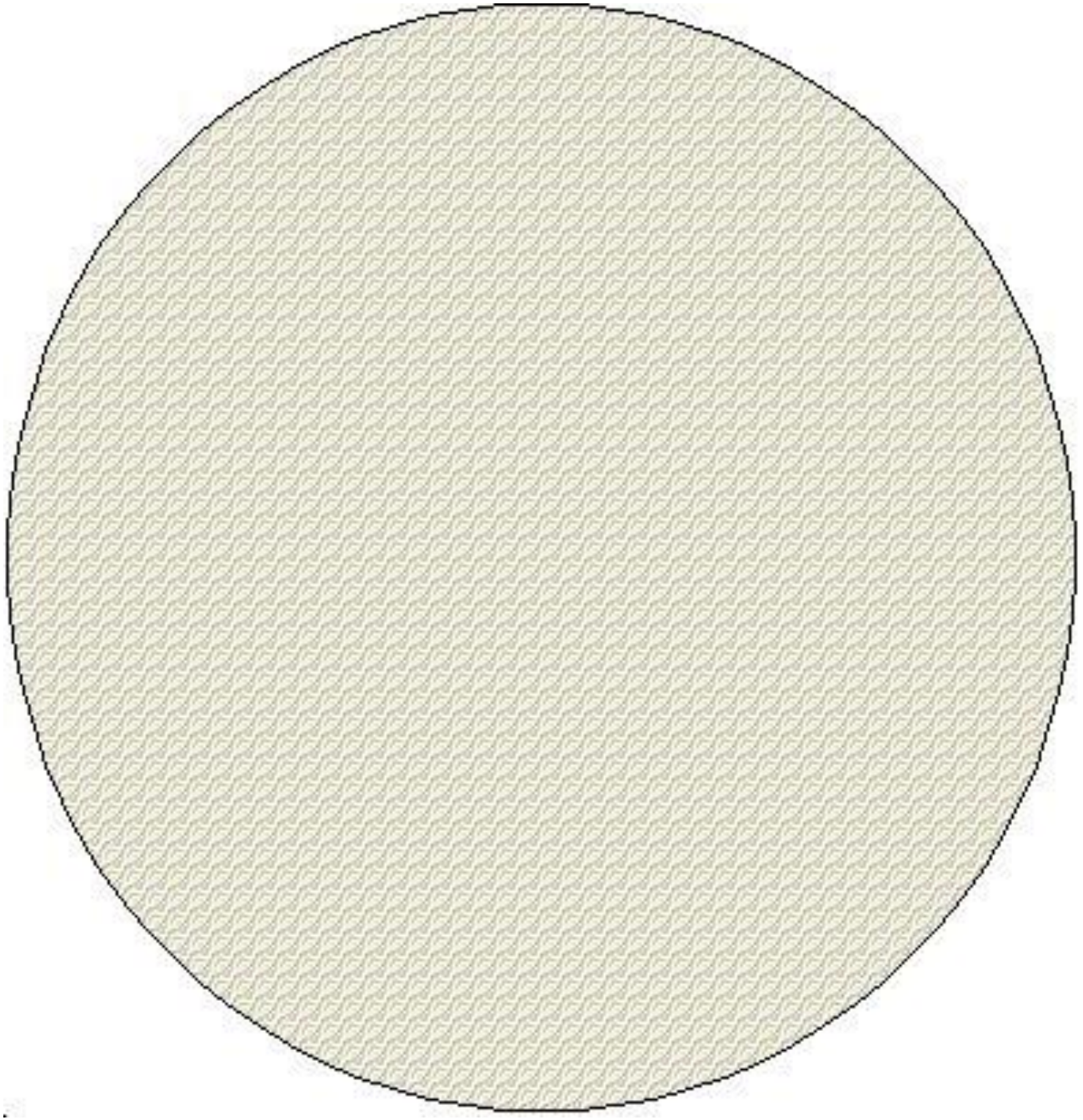
Noëns J.C. and J-L. Leroy (1981), "Measuring Electron Density in coronal active regions", Solar Phys. 73, 81-87

« High Resolution Observations of the Solar Corona: Why and How? » by S. Koutchmy and R. Smartt (1989), 10thNSO (SP) Workshop on High Resolution Solar Observationss, O. Von der Lühe Ed. p.560-575

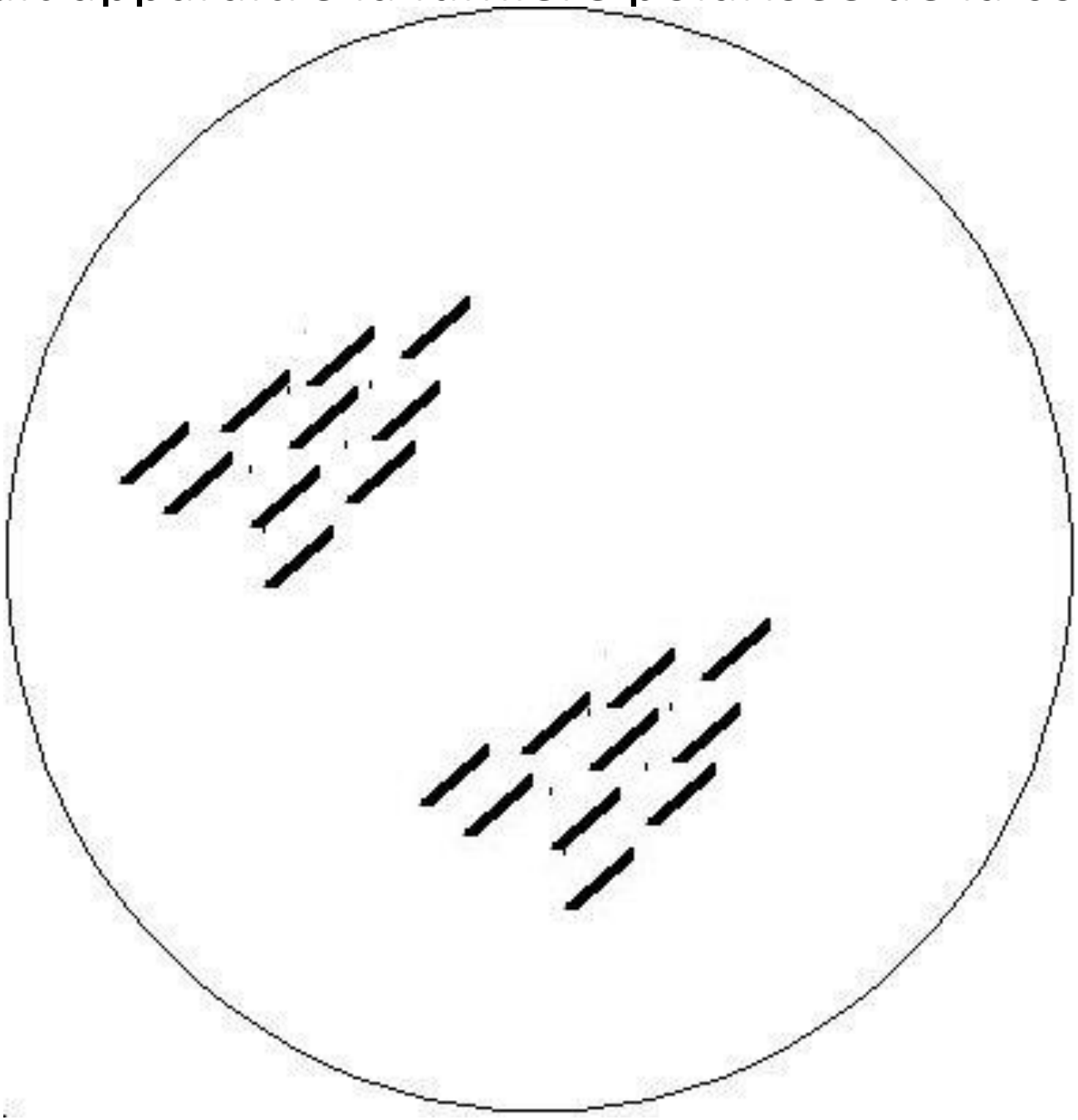
Depuis le sol, en lumière blanche l’image de la couronne est noyée dans la diffusion atmosphérique du fond de ciel dont la lumière n’est pas polarisée



En ne capturant que la lumière polarisée, on élimine la lumière du fond de ciel de l’image



Et on fait apparaitre la lumière polarisée de la couronne



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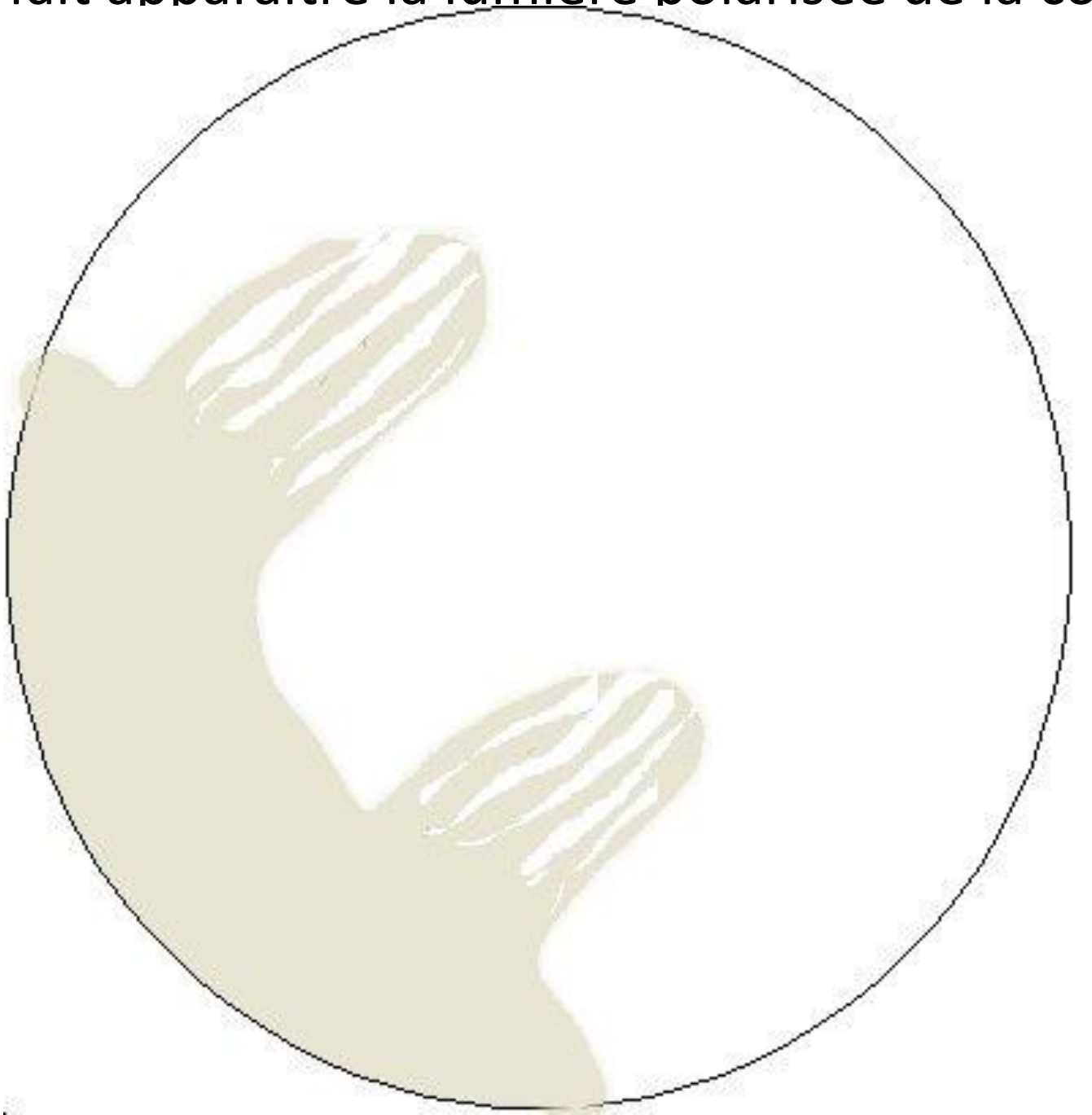
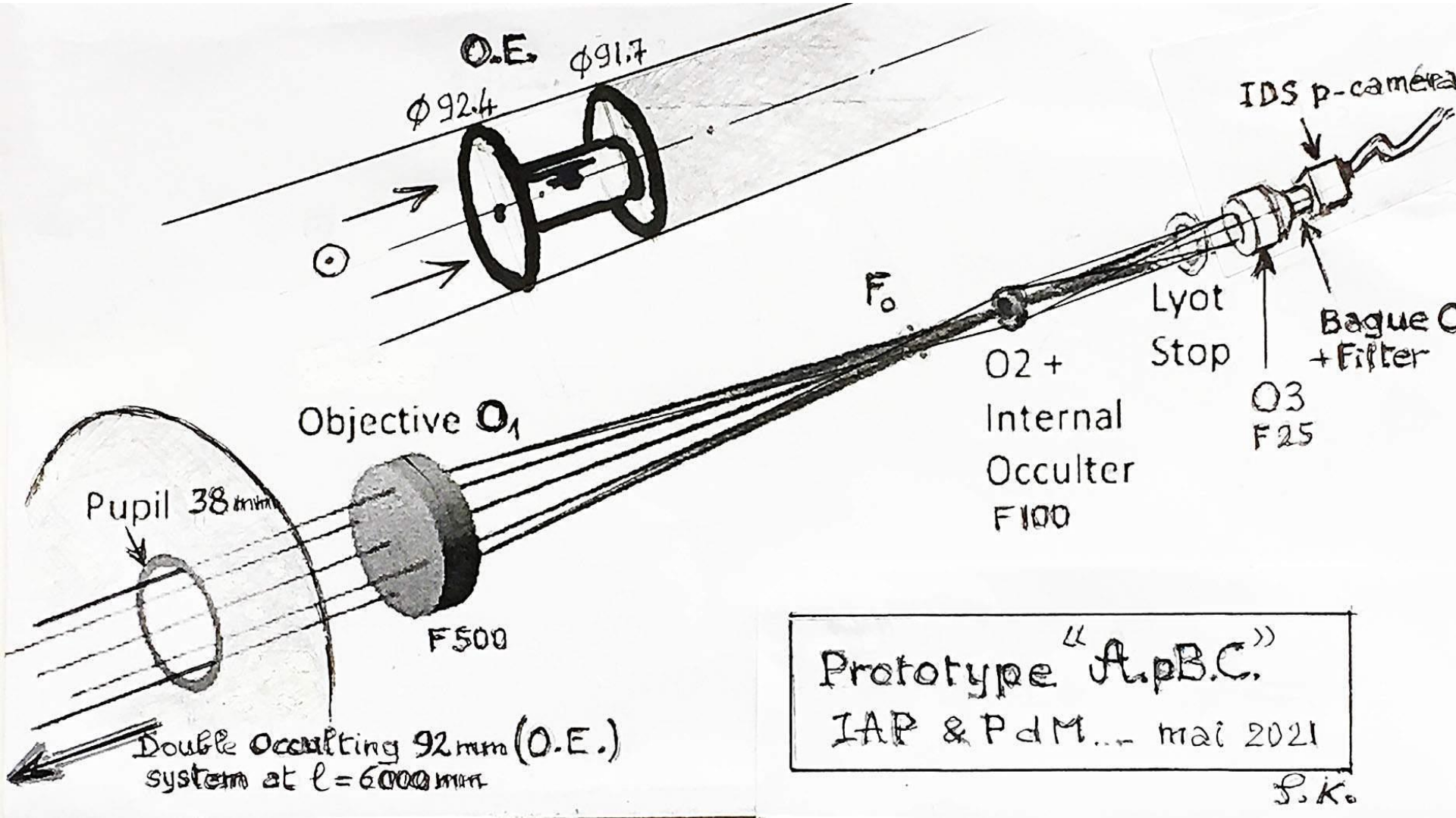
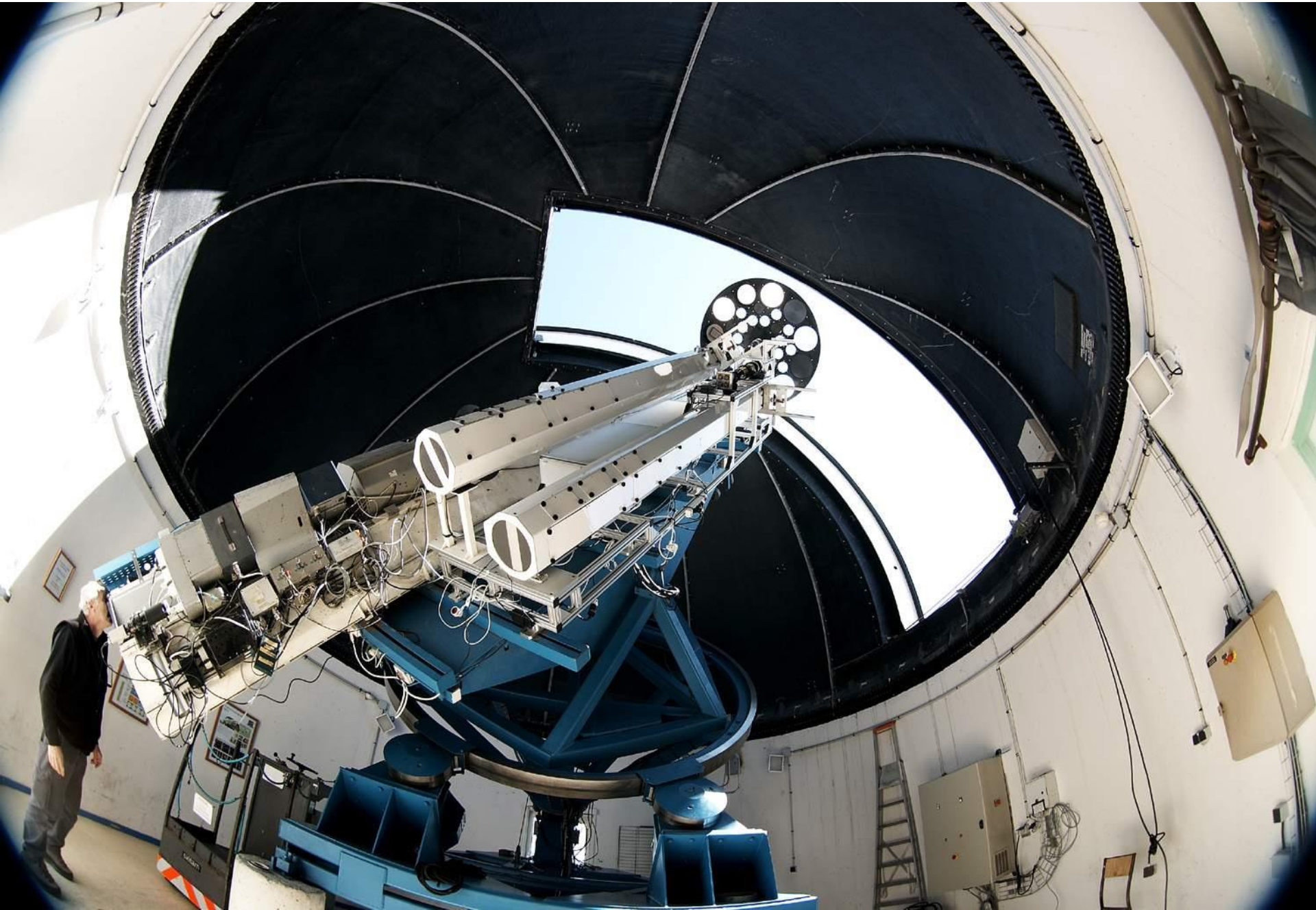


C’est ce que ce projet de coronographe à occulteur externe équipé d’une caméra polarimétrique devrait nous permettre de réaliser



La table équatoriale destinée à recevoir l'instrument



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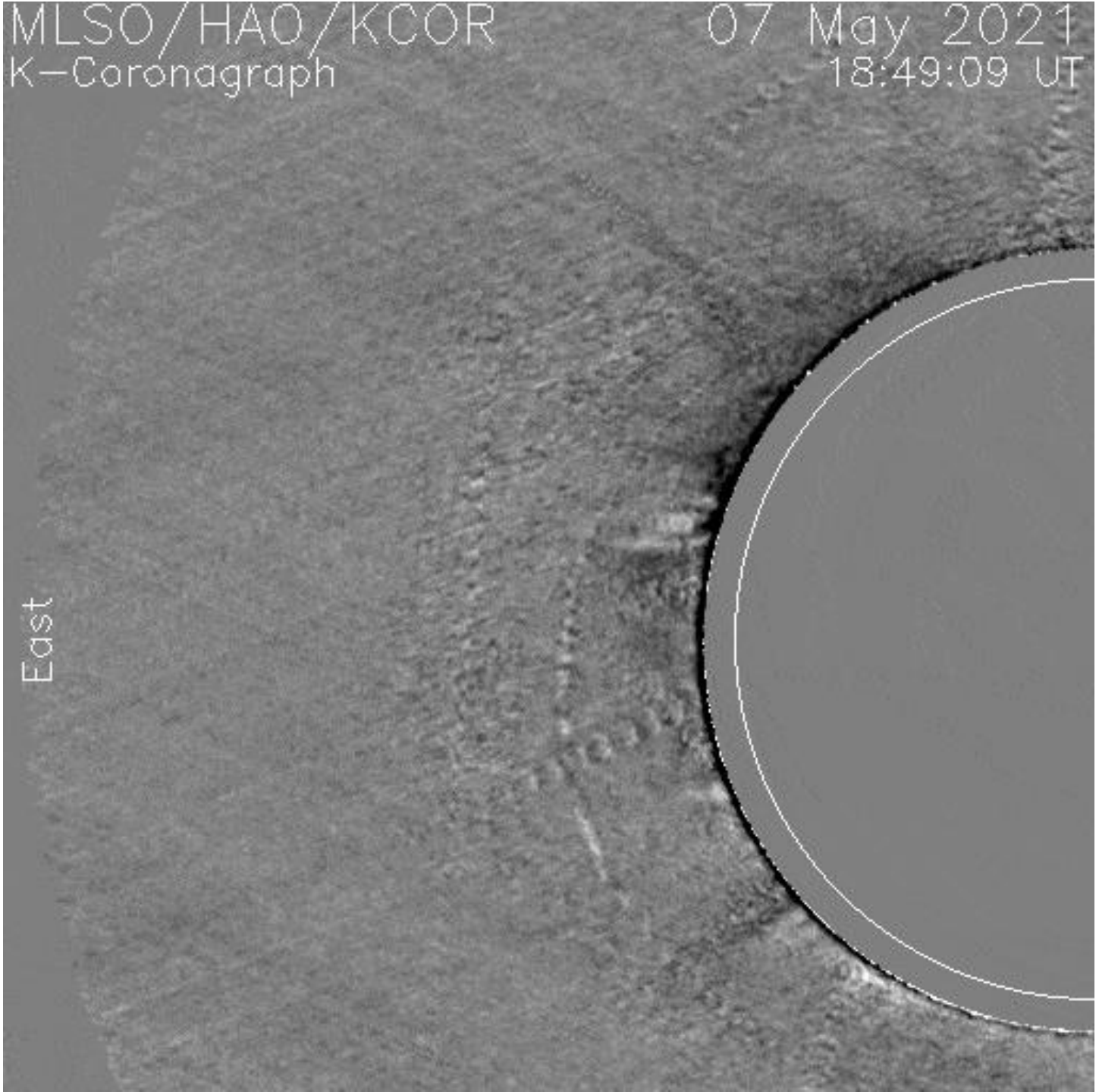
Pourquoi un coronographe à occultation externe au lieu du conception originale de Lyot ?

- Le grand chromatisme d'une lentille primaire rend impossible l'utilisation d'une grande gamme spectrale; l'ombrage de la lentille doublet d'entrée est nécessaire pour réduire considérablement (par 106) le niveau de la lumière diffusée à l'intérieur ;
- L'ombrage évite la chaleur dans le plan focal qui ajoute des turbulences internes, il évite également le diamètre variable du ou des disques d'occultation internes ;
- Le vignettage variable fourni par l'occultation externe permet une compensation du gradient radial des parties internes de la couronne (pas de données disponibles sur les membres très proches) ;
- Aberrations sphériques, de courbure de champ et d'astigmatisme difficiles à appréhender compenser en cas de grand champ de vision sont réduits ;
- Réduire les aberrations de polarisation dues à la biréfringence à l'intérieur du verre (inhomogénéités de température, effets de bord, contraintes) pour obtenir un une précision de 10-3 ou mieux en polarisation linéaire sur tout le champ permet de rejeter le grand fond non polarisé ;
- **Enfin l'utilisation de la nouvelle caméra polarimétrique rapide CMOS avec 5 Kpxs couverts avec des polariseurs linéaires dans 4 directions (0°, 45°, 90° et 135°) donne un grand multiplexage (par 106) par rapport à l'ancien polarimètre Lyot 2 canaux des K-coronographes**.

Occulteur déporté à l’extérieur


MLSO/HAO/KCOR
K-Coronagraph
07 May 2021
18:49:09 UT
East

Les OA c’est 60 observateurs bénévoles qui se relaient tous les jours de l’année et depuis bientôt 30 ans, par équipes de deux observateurs, et non une campagne ponctuelle

Merci de votre attention