IMAX Effect in Wide-field Polarizing Imagers

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Overview

The Polarimeter to Unify Corona and Heliosphere (PUNCH) will capture white-light polarimetric observations of the outer corona and heliosphere with a 90° field of view. Using Thomson scattering, it will derive 3D coronal structures and transients while linking their evolution to the heliosphere. A key challenge involves combining polarized observations at -60°, 0°, and +60° as the satellites orbit Earth, requiring adjustments to conventional Stokes parameters. The wide field also introduces polarization distortions, similar to the "IMAX effect." The solpolpy tool addresses these challenges and support PUNCH and other coronagraphs along with eclipse datasets.

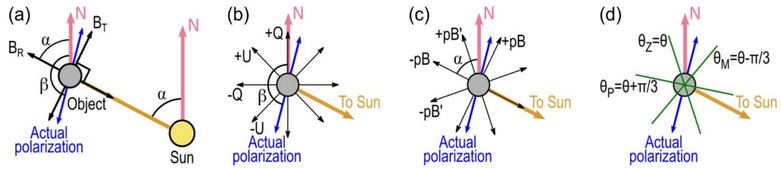
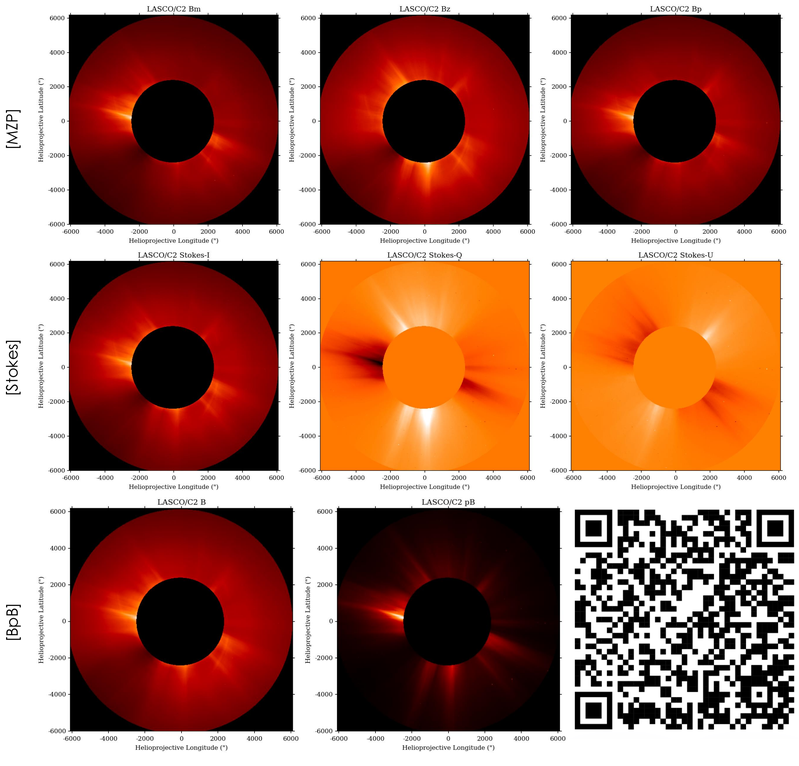


Figure 1: Linear polarization represented for solar corona (DeForest et al. 2022).

solpolpy

The polarization resolver being developed for PUNCH is known as the *solar polarization resolver in python* (solpolpy). solpolpy is based on the mathematics described in DeForest et al. (2022) and describes the polarization in any arbitrary oriented frame of reference. solpolpy can resolve *between* many polarization bases: tangential (B_T) and radial (B_R); Stokes I, Q and U; total brightness (B) and polarized brightness (pB); degree of polarization; and polarization triplet (Minus, Zero, Plus: MZP) measurements (Figure 1).



IMAX Effect:

The wide FOV of PUNCH/WFI induces the challenge of resolving proper polarizing angles, which was identified in an IMAX 3D movie. The wide angular span of the FOV not only distorts the shape but also the inscribed angles viewed from different regions of the FOV. This becomes important for PUNCH due to its large FOV and the objective of measuring polarization in the heliosphere, where the anticipated signal is very faint as compared to the solar disk.

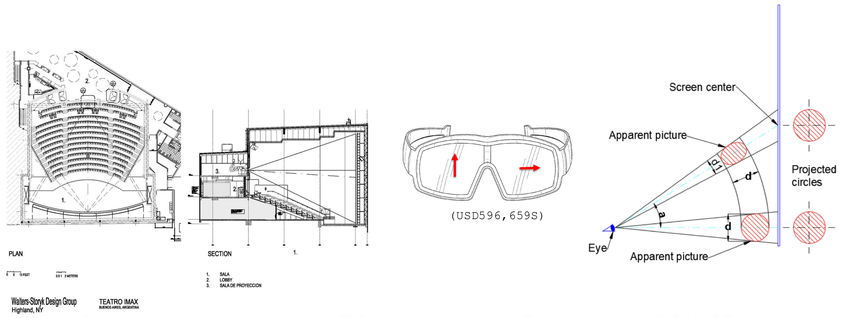


Figure 3: left: An example wide screen IMAX theatre, *middle:* Polarizer-based IMAX-3D glasses, *right:* Distortion of a circular image due to the wide viewing angle.

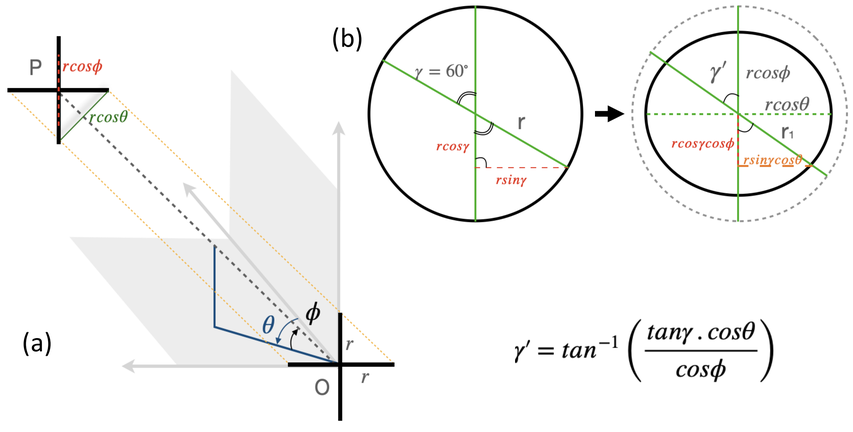
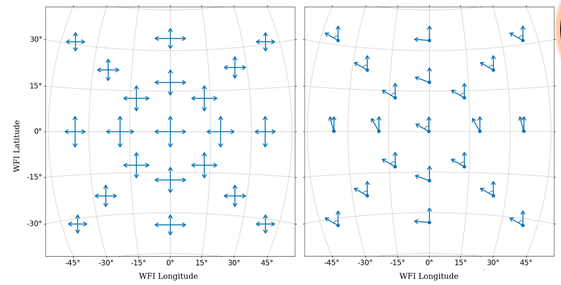


Figure 4: (a) Measurement of polarization angle variation within PUNCH/WFI FOV considering the orthographic projection. (b) Example circle (left) and projected ellipse (right), which affects the angle γ as a function of position (θ,ϕ).



Scan this to check an interesting visualizatio n with solpolpy

Figure 5 Left to right: : Perceived lengths in two orthogonal directions and polarizer angles as a consequence of IMAX effect for a wide field of view derived from the steps on Figure 4. The distortion is exaggerated in the two panels for illustration purpose.

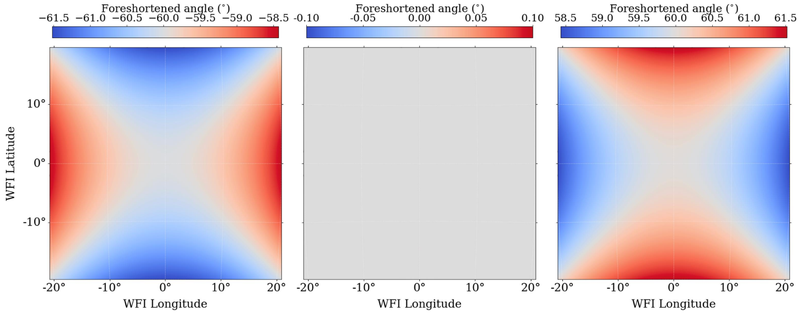
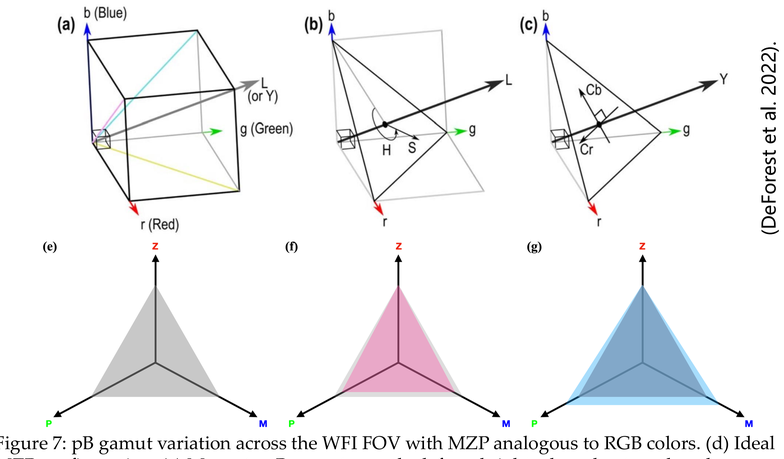


Figure 6: Foreshortening of angle across the WFI FOV (originally all -60°, 0° and 60° respectively) .



(DeForest et al. 2022).

Figure 7: pB gamut variation across the WFI FOV with MZP analogous to RGB colors. (d) Ideal MZP configuration. (e) Magenta pB gamut near the left and right edges due to reduced polarizer foreshortening. (f) Blue pB gamut near the top and bottom edges due to enhanced foreshortening. Grey shading in (e, f) indicates the ideal gamut from (a).

Summary

The basic structure of the polarization resolver has been developed and tested for existing datasets of the LASCO and STEREO coronagraphs. We also implemented the IMAX effect while resolving the polarization for PUNCH/WFI images. This has been integrated with the reprojection module to make composite mosaics so that the final PUNCH data products can be represented as a B, pB pair w.r.t solar north. Follow the Github QR code on the right to access an example notebook under the solpolpy repository.

Reference: DeForest et al. (2022b) ApJ, 927, 1

For any queries and/or suggestions email me at ritesh.patel@swri.org