Coronal White Light 3D Reconstruction

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Goal

- Develop, Test, Apply 3D reconstruction techniques to solar features from low corona through heliosphere to 1 AU.
- Utilize B, pB, temporal, 2D white light coronagraph images and synthetic models from 2 vantage points, construct (time dependent) 3D electron density distribution

Learn to Walk before Running...

Science

- Polar Plumes - hydrostatic equilibrium sol'n of density vs. height, tube expansion, statistics
- Equatorial Streamers - projection of sheets, effect of AR's, compare to 3D recon tie points (Liewer 2000), density enhancements vs. folds
- CME's - models - prepare for SECCHI, effect of observing angle, speed, etc.

Key Aspects

- Renderer - Physics (Thomson scattering), geometry, optically thin plasma
- Reconstruction Algorithm - PIXON, underdetermined system, speed (large # pts)
- Visualization - 3D electron density distribution, time dependent
- Data - LASCO polar plumes, streamers include 3D densities rendered from tie points, synthetic CME models

PIXON - What

- Pina, Puetter, Yahil (1993, 1995) - high performance, non-linear, non-parametric, locally adaptive, iterative image reconstruction
- Commercial package - used in radio, HXT, remote sensing, etc; develop specific code jointly - tomography from limited (2) views - mostly developed from SBIRS; data sampling fcn - renderer/transpose; visualization
- Full 3D reconstruction of Ne

PIXON - Why

- Standard tomography-not applicable, parametric least squares - too slow; maximum entropy methods do not work well on local variations; minimum complexity solution - works locally fewer artifacts
- Speed of 3D reconstruction - scales as N, estimates <10 iterations - intelligence stop when declining complexity per iteration drops 512x512=2 min,256x256x256 ~2hrs,

PIXON - Details

- Simple Problem, D=observation, I=reconstructed image, H=PSF, K=pixon kernel, Φ=pseudoimage, N=noise

  $$D(x) = \int dy H(x,y) I(y) + N(x)$$

  $$I(y) = \int dz K(y,z)\, \Phi(z)$$

- 2 Step soln a) minimize χ^2 by Φ, b) minimize # pixons and maximize size locally - each part is iterative and iterate steps
- PIXON shapes - spherical, can change

Conclusions

- 3D reconstructions are possible
- Direct application to SECCHI will require substantial effort and collaboration