Study of Interplanetary Magnetic Field with Atomic Alignments

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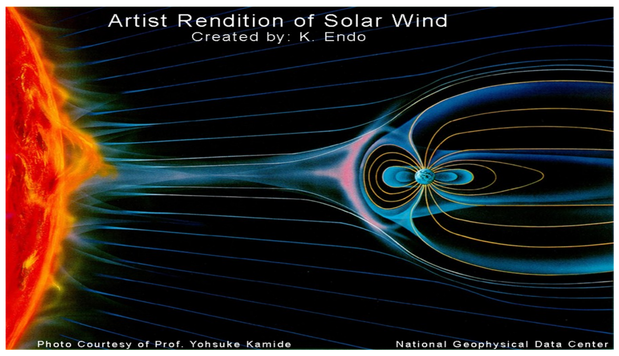
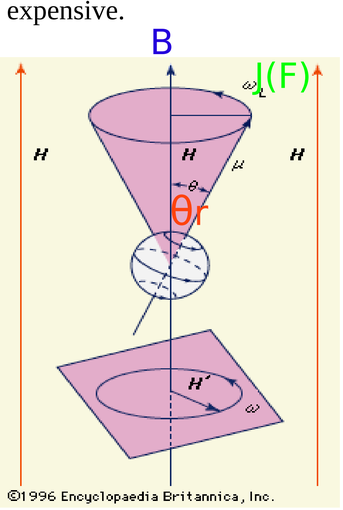
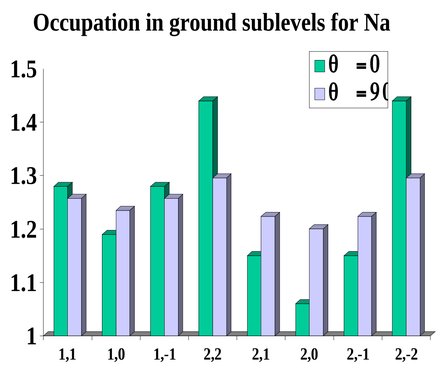
Interplanetary magnetic field is quite important for us to understand the space environment. It may influence the Earth directly and also contribute to form macro structures.



Techniques on magnetic field diagnostic:

- Zeeman splitting—providing a good way to get the magnetic field strength, but time consuming and only being applied to the strongest magnetic fields in the universe.
- Space probe—able to give accurate data of magnetic field, but only local information of the magnetic field on the trajectory of the probe and very expensive.



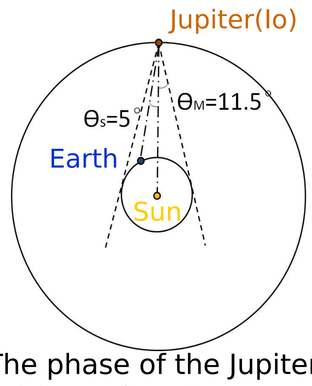


Atomic Alignment (with magnetic mixing effect on the ground level) is sensitive to the direction of the magnetic field and can be applied to general diffused media with magnetic strength below 1G.

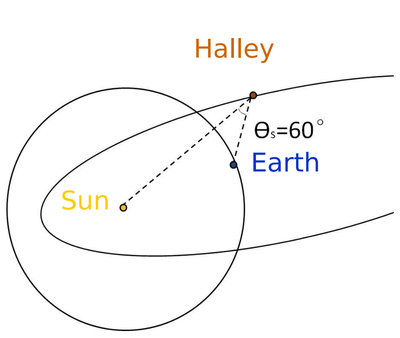
Synthetic Observation of the Io* and Comet Halley, motivated by the fact that there are abundant Sodium there.

*Io is the innermost of the four Galilean moons of planet Jupiter.

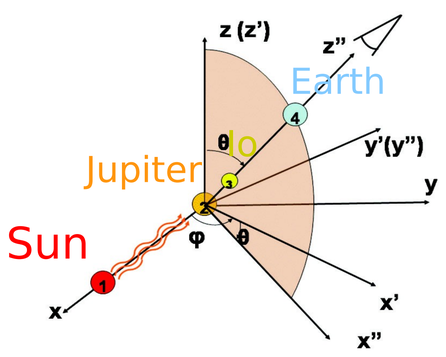
The geometry employed:



The phase of the Jupiter is set to be $\theta_S=5°$



The phase of Comet Halley is set to be $\theta_S=60°$

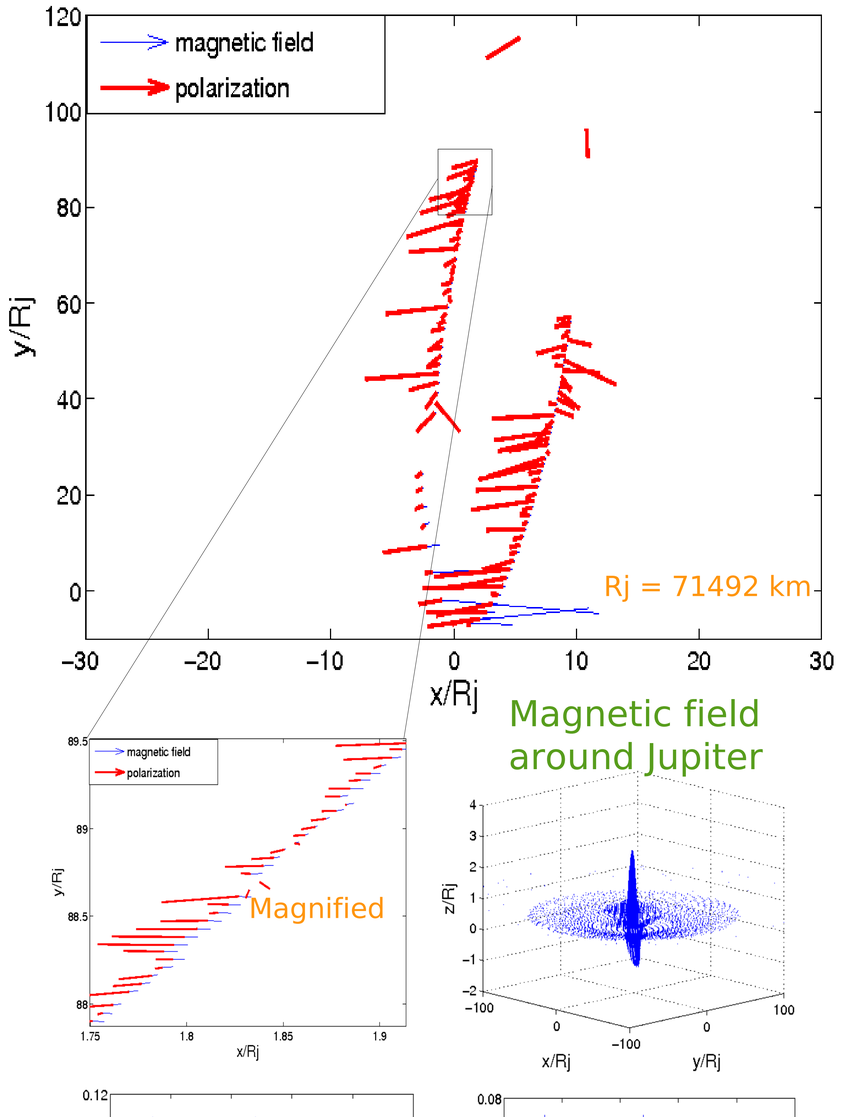


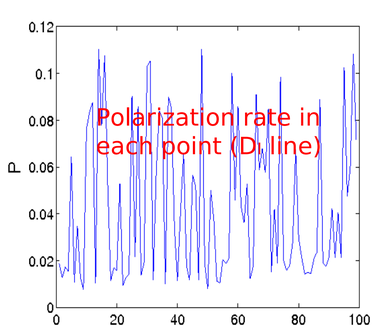
The synthetic observation geometry.

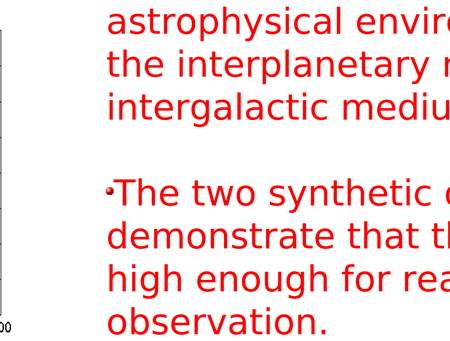
ABSTRACT

Instead of sending thousands of space probes, atomic alignment, a promising way to study interplanetary magnetic field, allows magnetic mapping with any ground telescope facilities. The polarization of spectral lines that are pumped by the anisotropic radiation from the sun is influenced by the magnetic alignment. As a result, the linear polarization becomes an excellent tracer of the embedded magnetic field. The method is illustrated by our synthetic observation of Io and comet Halley.

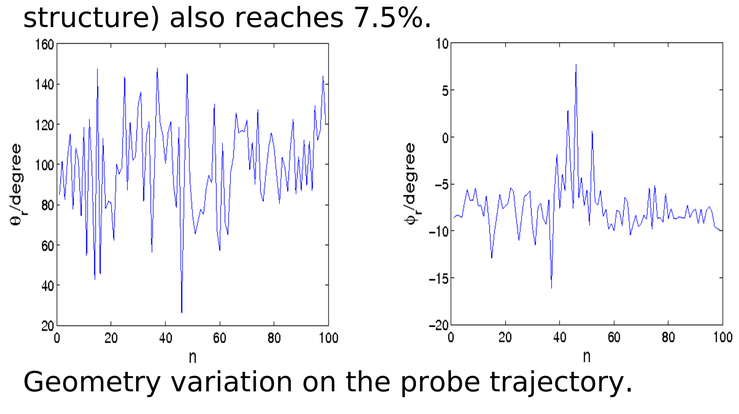
Polarimetric observation of Io





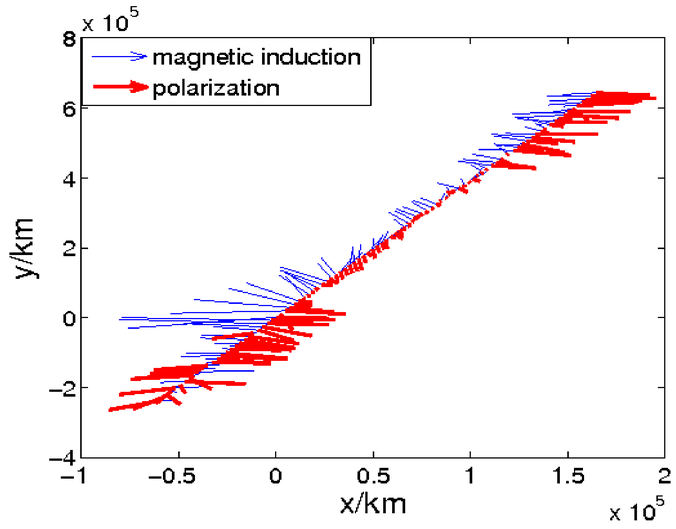


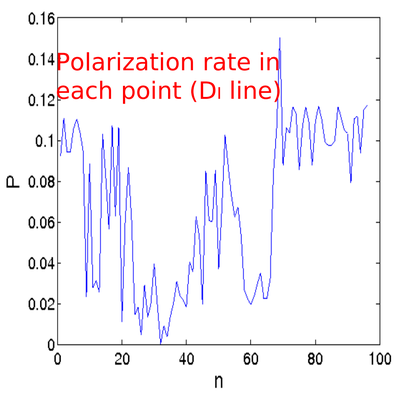
The polarization rate of DI line reaches 11% and the rate of D line (namely, do not solute the fine structure) also reaches 7.5%.

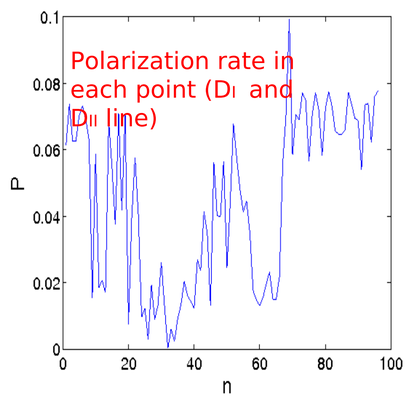


Geometry variation on the probe trajectory.

Polarimetric observation of Comet Halley







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Summary

- Atoms and ions with fine(or hyperfine) structure J(or F)>1 can be aligned in their ground state.
- Atomic alignment provides a promising method to detect the weak magnetic fields in diffused medium.
- Atomic alignment is sensitive to the direction of the magnetic field.
- This method can be also applied in many astrophysical environments, for example, the interplanetary medium, the ISM and the intergalactic medium.
- The two synthetic observations demonstrate that the polarization degree is high enough for real spectropolarimetric observation.
- Atomic alignment provides a cost effective way of studying 3D interplanetary magnetic field.

Reference:

Shangguan, J. & Yan, H. 2011, ApJ, submitted

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