MONTE CARLO MODELING OF RADIATIVE TRANSFER IN COMETS: A SEARCH FOR MECHANISMS GIVING CIRCULAR POLARIZATION.

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Introduction: Light scattered in some comets has been observed to be circularly polarized (see e.g. [1]) The observed values of the degree of circular polarization (q hereafter) are close to zero but appreciable compared to the error bars ($q \geq 0.1\%$), positive and negative values are observed and they are highly variable in time (more than 100% in a few minutes). Several mechanisms have been proposed to explain these observations (see e.g. [2]), all of them dealing with properties of the dust particles that scatter light at the coma of the comet. But none of them take into account the contribution of an asymmetrical nucleus. The present work is a first step in this direction.

Necessary condition for circular polarization: Light scattered by a perfectly azimuthally symmetrical comet (nucleus and coma symmetrical) around the direction of the incident light cannot be circularly polarized because of symmetry arguments: both rotating around the symmetry axis, and applying mirror symmetry with respect to a plane through the same axis, should be equivalent transformations leaving the system in the same state. Nevertheless, the second one changes the handedness of the circular polarization observed in a particular direction, while the first one doesn't (see Fig. 1). Hence, circular polarization through scattering by a system with azimuthal symmetry around the direction of the incident light is not possible.

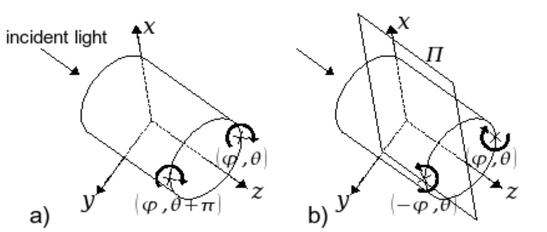

Figure1: Transformations of circularly polarized light observed at a certain point, under a rotation of π rad around the direction of the incident light (a), or an equivalent mirror symmetry with respect to a plane trough this direction (b). φ and θ are the usual cylindrical coordinates.

Description and model validation: In order to save space we refer to [3,4] for a detailed description of the model. Just as a benchmark assumption for the current calculations, we assumed that the nucleus surface has zero albedo.

As a finite number *NPACK* of photons is launched, we have to check whether the number we use is high enough as to give a good statistics. The condition coming from the previous section gives us a test: using a spherical comet, we increase *NPACK* as the computational cost grows up until $q \simeq 0$ for all scattering angles θ (the angle formed by the directions of the incident and the scattered beams). A first calculation using *NPACK*$=10^7$ has been performed, and the results are presented in Fig. 2.

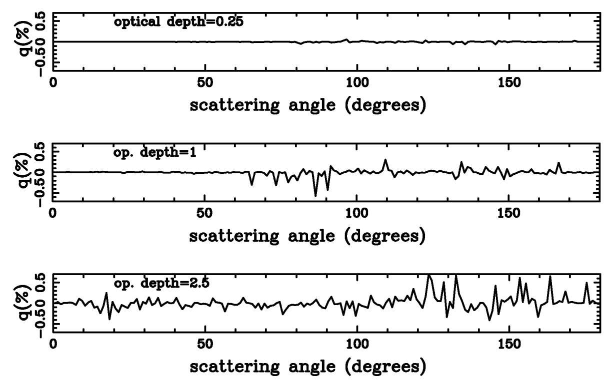

Figure2: Degree of circular polarization as a function of the scattering angle for three *optical depths* of the coma. $\theta=0$ corresponds to the forward direction. *NPACK*$=10^7$ was taken.

As seen in Fig. 2, the error of q for a fixed *NPACK* increases as the optical depth τ does. This is because photons become more prone to undergo more scattering events as τ increases. But even for $\tau=0.25$, 10^7 launched packets of photons are not enough (q=0.05% is reached).

Future work: Further calculations using the same model with larger values of *NPACK* are necessary, until the obtained values of q become negligible. Retrieving the degree of linear polarization and comparing with observations and previous simulations is another outstanding task. Reflections on the nucleus and an asymmetrical geometry around the direction of the incident light should be introduced in the model afterwards.

References:

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