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Predominantly left-handed circular polarization in comets: Does it indicate L-enantiomeric excess in cometary organics?

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Abstract. Polarimetric observations demonstrated that all comets with significant values of circular polarization show predominantly left–handed circularly polarized light. We discuss the presence of homochiral organics in cometary materials as a source of the observed circular polarization. We have studied the effect of chirality on light–scattering properties of cometary dust considering particles that possess optical activity. Our investigations show that the cometary dust may include optically active materials which can be prebiological homochiral organics.

Keywords. Comets, observations, polarization, light scattering

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Recent observations confirmed that the light in the optical continuum of cometary spectra is circularly polarized. There are several mechanisms that may be responsible for the circular polarization (CP) in comets. Among them is scattering of light on particles containing optically active (chiral) materials. Optical activity is concerned with chirality (mirror asymmetry) of molecules and is typical for complex organics. A characteristic property of terrestrial bio–organic molecules is that their amino–acids are left–handed and the sugars are right–handed (called "homochirality"). For a long time it was believed that homochirality, or asymmetry in the number of L and D biomolecules, is of terrestrial origin. But then a significant excess of left–handed amino–acids was found in carbonaceous materials of meteorites (Cronin & Pizzarello 1997, Pizzarello 2004 and references there), suggesting its origin in the pre–solar nebula. Moreover, high values of CP were discovered in star–forming regions and their possible connection to a fundamental problem of astrobiology, homochirality of biomolecules, was widely discussed (Bailey 2000, Bonner & Bean 2000, Meierhenrich & Thiemann 2004, Nuevo *et al.* 2007). It was shown that the photolytic processes, which involve circularly polarized light, may provide a viable mechanism for chiral selection of organic molecules. It is well known that primitive meteorites, interplanetary dust, and comets contain complex organics. This allows us to suppose that primitive solar–system bodies, including comets, may be reservoirs of homochiral organics. In our investigation we focus on a search for chiral organics, which can be detected remotely, by studying CP of the light scattered by cometary dust.

The results of available polarimetric measurements of CP are summarized in Figure 1. As one can see, the observations indicate noticeable circular pllarization in comets and clearly show its systematic trend with the phase angle. Furthermore, CP in the observed comets is predominantly left–handed.

We simulated results of the observations considering light–scattering by particles whose material contained some excess of chiral organics, and, as a result, possessed some optical

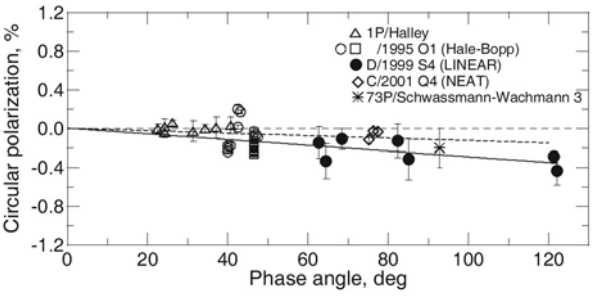

Figure 1. Composite phase–angle dependence of circular polarization for comets 1P/Halley (Dollfus & Suchail 1987), C/1995 O1 (Hale–Bopp) (Rosenbush, Shakhovskoy & Rosenbush 1997, Manset & Bastien 1997), D/1999 S4 (LINEAR) (Rosenbush *et al.* 2007b), C/2001 Q4 (NEAT) (Rosenbush *et al.* 2007a), and 73P/Schwassmann–Wachmann 3 (Tozzi *et al.* 2006). The solid line is the linear fit to the observed data, dashed line represents results of our calculations for optically active (chiral) spherical particles.

activity (for details see Rosenbush *et al.* 2007b). The simulations were done using the theoretical solution for optically active spheres (Bohren & Huffman 1983). To make the calculations more realistic, we considered particles with the power–law size distribution measured *in situ* in comet Halley. We used the optical constants typical for the amino–acids discovered in the Murchison meteorite (Cronin & Pizzarello 1986). Under these conditions we could obtain the observed phase–angle trend of CP, although it does not reach values larger than 0.15% at the phase angle equal to 120°. More realistic model of cometary dust as aggregates of submicron particles can significantly increase the value of CP as multiple–scattering effects get involved. This, together with the spectroscopically detected enriched organic composition of comets, allows us to reasonably speculate that CP in comets indicates the presence of prebiotic homochiral organics.

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