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Analysis of polarization in the innermost coma in Comet 81P/Wild 2: Implication to the Stardust findings

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The low abundance of refractory carbonaceous material in samples collected by Stardust at its closest approach to the comet 81P/Wild 2 nucleus (about 240 km) was completely unexpected [Ishii et al., 2008, Science 319, 447–450]. Carbon is an essential component of organic material, which is thought to be formed in the interstellar medium. Comets presently observed in the solar system are believed to be remnants of planetesimals that contained organic materials and/or amorphous carbon and are expected to preserve pristine material of the interstellar medium.

Polarimetric imaging of comets provides evidence that different types of dust are present in different regions within the cometary coma. For instance, the innermost coma produces a strong negative polarization of up to -6%, which is called the circumnucleus polarimetric halo [Hadamcik & Levasseur-Regourd, 2003, J. Quant. Spectr. Rad. Trans. 79-80, 661–678]. The halo is typically a few thousand kilometers across that is much smaller than the size of the whole coma. Such a circumnucleus polarimetric halo also was found in comet 81P/Wild 2.

We investigate the mechanism governing the phenomenon of the strong negative polarization with the discrete dipole approximation (DDA) and the model of irregularly shaped agglomerated debris particles. In our modeling we take into account the size polydispersity of agglomerated debris particles so it is similar to what was measured in situ in comets. We compute light scattering by agglomerated debris particles at various degrees of material absorption and found that the strong negative polarization in the innermost coma ultimately suggests the lack of highly absorbing materials. However, most carbonaceous materials are highly absorbing; therefore, our finding implies the depletion in the innermost coma of such materials. We draw attention that this finding is consistent with the Stardust findings.

We emphasize that the circumnucleus polarimetric halo that produces a strong negative polarization is only a small part of the whole coma. The degree of linear polarization in other parts of the coma is much less negative. Moreover, some features, such as cometary jets, do not reveal any negative polarization at all [Hadamcik & Levasseur-Regourd, 2003, J. Quant. Spectr. Rad. Trans. 79-80, 661–678]. This feature can be interpreted in terms of high abundance in carbonaceous materials. Note, more detailed report of the present research can be found in [Zubko et al., 2012, A&A 544, L8].