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# Are large organic molecules in comets similar to the Diffuse Interstellar Bands carriers?

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## Abstract

We suggest that the refractory organic material found by COSIMA in 67P/CG comet dust (Fray et al., 2016) is made of aggregates of the same organic molecules which are present in the interstellar medium (ISM) and are producing in observed stellar spectra the absorptions called Diffuse Interstellar Bands (DIBs). Such a link would increase the scientific interest of a comet sample return mission, addressing both comets and interstellar material. The refractory character of comet organic matter does not necessitate a cooled return capsule, an important sample return mission cost-driver.

## 1. Introduction

One major outcome of the Rosetta space investigation of the nucleus of comet 67P Churyumov-Gerasimenko is the idea that this comet is the result of a gentle, hierarchical process, growing slowly from interstellar material up to the size of the nucleus (Davidsson et al., 2016). Therefore, the interstellar material which formed the proto-solar nebula is likely to have been preserved pristine at the distance of formation of comets, and still be present in the nucleus.

## 2. Diffuse interstellar Bands (DIBs)

The diffuse interstellar bands (DIBs) are more than 500 irregular weak absorptions in optical and IR stellar or galaxy spectra (figure 1). According to observed DIB properties and correlations, DIB carrier candidates should primarily be sought among carbon-based organic molecules in the gaseous phase and not in dust grains. They probably constitute "… the largest reservoir of organic matter in the Universe" (Snow, 2014).

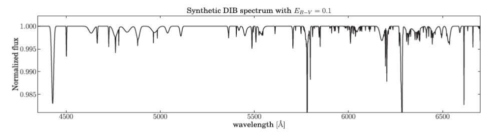


Figure 1: A synthetic spectrum of DIB absorption representative of a line of sight with E(B − V) ~0.1 mag. Note the expected absorption is at the 1 per cent level. From Lan et al., 2015 and references therein.

We are reproducing on Fig. 2 some of the equivalent widths (EW) curves of Lan et al. (2015), normalized at 1 for a color excess E(B-V)= 0.4. It is clear that equivalent widths of these mono-cloud observations acquired outside of the galactic plane all start to increase proportionally with extinction (measured by the color excess). Then they **all** stop to increase linearly (in a log plot) with the color excess E(B-V) and instead seem to level-off (saturate) above E(B-V) ≈ 1, i.e. again when sightlines cross very dense cloud cores, or even begin to **decrease** above E(B-V)= 0.4 for some of them.

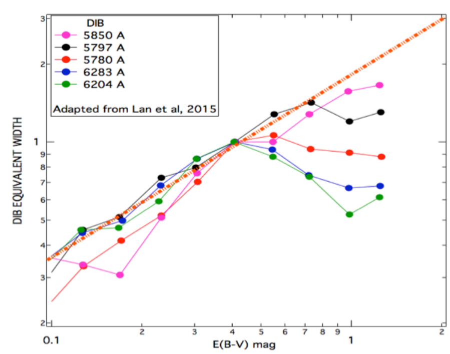


Figure 2: Average DIB equivalent width as a function of the color excess along the line-of-sight, for five strong DIBs. The data are taken from Fig. 8 panels of Lan et al. (2015). All curves have been

scaled to EW= 1 at E(B-V)= 0.40. The dashed-dotted line serves as a guide to visualize departures from linearity above this color excess value.

Some DIBs start to deviate from proportionality to the dust column at a lower color excess compared to the other 5797 Å and 5850 Å DIBs. However, **all** DIBs tend to saturate or even decrease. Having in mind that the LOS crosses a single cloud, we may assign large extinctions to LOS crossing the center of a cloud, while more modest extinctions suggest LOS crossing more external parts of a cloud. We suggest that these recent observations of global DIB leveling-off in cloud dense and UV-shielded cores are simply due to the fact that in the dense cores the DIB carriers do not exist but instead are part of a solid phase of organic material, their "parent" material. If this happens in existing molecular clouds, it may have happened also in the molecular cloud from which was formed our solar system, suggesting the relevance to organic matter in comets.

## 3. Carbon inventory of DIB carriers in the ISM and in comets.

With some reasonable assumptions, we could derive from the Equivalent Widths of all visible (Hobbs et al., 2009) and Infra red DIBs (up to 1.5 µm) that at least 30 % of interstellar carbon is locked up in a DIB carrier, yielding a ratio $R_{ISM}$ of organic to minerals of about 0.32 (Bertaux and Lallement, 2017). This is comparable and similar to a value $R_C \approx 0.5$ organic to minerals as reported by COSIMA team (Baklouti et al., 2017) which reported the presence of refractory large organic molecules in the dust particles collected at Rosetta spacecraft (Fray et al., 2016). The simplest explanation for this similarity of $R_C$ and $R_{ISM}$ is that the ISM organic material has been directly incorporated in comets without major chemical processing (except perhaps for some re-hydrogenation). Following the Occam's razor principle claiming that the simplest explanation is the most likely, we adopt this explanation.

## 4. Conclusion

The connection between DIB carriers and comet nuclei increases substantially the scientific interest of a comet sample return mission for the study of both comet and ISM materials. Since this cometary organic material is refractory, the sample return capsule does not need to be maintained at cool temperatures to preserve ices, a technical requirement that increases considerably the cost of a comet sample return mission.


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