Can grain-surface chemistry explain the surprisingly low C/CO ratio in the HD 32297 debris disk?

G. Cataldi,[1,2] Y. Wu,[3] A. Brandeker[4] , N. Ohashi[5], A. Moór[6] et al.

[1]*National Astronomical Observatory of Japan, Japan*
[2]*Department of Astronomy, Graduate School of Science, The University of Tokyo, Japan*
[3]*Department of Astronomy & Astrophysics, University of Toronto, Canada*
[4]*Department of Astronomy, Stockholm University, Sweden*
[5]*Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan, R.O.C.*
[6]*Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungary*

Debris disks are analogues of the solar system's asteroid and Kuiper belt. They consist of kilometer-sized rocky or icy bodies ("exocomets") that continuously collide and produce dust. However, in recent years observations of CO emission have shown that some of these objects also contain substantial amounts of gas [e.g. 1]. Like the dust, this gas is probably produced by collisions of cometary bodies. It is important to understand the nature of this gas for a number of reasons. For example, the gas allows us to study the composition of the exocomets [e.g. 2]. Furthermore, the gas might be accreted by planets, thereby changing their atmospheric composition [3].

The A-type main sequence star HD 32297 (age of 15-30 Myr) hosts a debris disk with a high CO mass. Since CO is quickly photo-dissociated by the interstellar radiation field, it has been suggested that CO is shielded by neutral carbon atoms that are produced by the photo-dissociation [4]. This would allow a large CO mass to accumulate from the collisional destruction of icy exocomets. In order to test this scenario, we observed neutral C emission with ALMA towards HD 32297 [5].

In order to interpret our observations, we set up a simple model where CO is produced from cometary bodies and destroyed by the interstellar field, taking into account CO self-shielding and shielding by neutral C. We find that the observed C/CO ratio can only be explained if 1) the CO production rate is uncomfortably high and 2) C is removed from the system on a short time scale by an unknown process. We hypothesize that grain surface chemistry might solve this puzzle: C and O atoms might accrete onto dust grains and re-form CO, which is than re-released to the gas phase. This would provide an additional CO source and a C sink, therefore explaining the surprisingly low C/CO ratio. However, a more detailed examination with the help of grain surface chemistry experts is needed in order to assess whether this is a realistic scenario.

References

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