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Light Induced Dust Lifting on Mars: 0g Experiments

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Abstract

Experiments showed that dust beds continuously eject small, micron sized particles under illumination at mbar pressure [3, 6]. Temperature gradients within the illuminated dust bed induce forces (photophoresis, Knudsen compressor effects) which eject surface particles. We discovered in micrograving experiments that this effect is not linear with gravity (g-levels) but follows a $1/g$-function and hence is very efficient at small g-accelerations. The ejection mechanism helps to solve the problem of lifting dust on Mars. At the low atmospheric pressures (mbar) on Mars wind speeds are in general to low to lift dust particles by gas drag alone [2, 5] . Wurm et al. (2008) [7] reported that photophoretic particle ejections actually work on Mars. In this presentation the results of microgravity particle ejection experiments are presented.

1. Introduction and Experiments

The continuous particle ejections of an illuminated dust bed is caused by a solid state greenhouse effect and photophoresis [3, 6].

Illuminated dust beds develop and inverse temperature gradient pointing from a subsurface temperature maximum (solid state greenhouse effect) towards the cooler surface [4]. The dust bed heats up due to absorption and only the surface can cool by thermal radiation. Hence, the temperature maximum is within the dust sample slightly below the surface covered by a few layers of dust aggregates [4]. The surface aggregates therefore have a temperature gradient.

At low ambient pressures (mbar) particle with a temperature difference over their surface experience a photophoretic force which accelerates the particle in general in the direction from warm to cold. In the case of the illuminates dust bed this direction is – due to the solid state greenhouse effect – away from the surface. If the photophoretic force overcomes cohesion and gravity, the surface dust aggregates are released from the dust bed into the surroundings (Fig.1). Typical pressures needed are some mbar at several

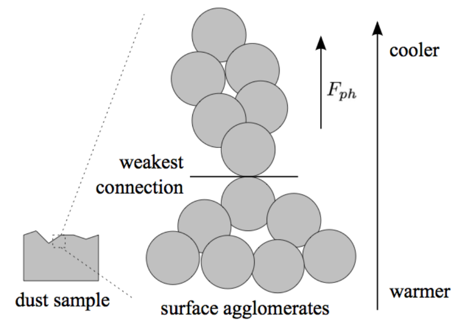

Figure 1: Principle of photophoretic force acting on dust particles [3].

kW/m^2 light intensity.

In 0g-experiments (0g,1g,2g) we explored the influence of gravity on the ejection effect in order to better understand the relevance of this effect on dust phenomena on Mars. The experiments showed that the ejection rate highly increases at g-levels $\ll$ 1g and are nearly negligible in 2g (Fig.2, Fig.3). We found that

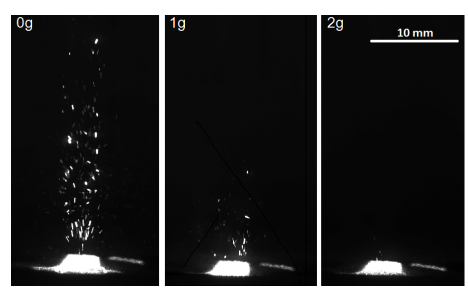

Figure 2: Example of dust eruptions in different g-levels with 5mbar ambient pressure.

the number of ejected particles N (mass loss rate or erosion) follows a $1/g$-function of the form

$$N \propto \frac{1}{d \cdot g + 1}, \quad (1)$$

(Fig.3) where g is the gravitational acceleration and d is a factor of all unknown parameters like e.g. particle properties or gas parameters.

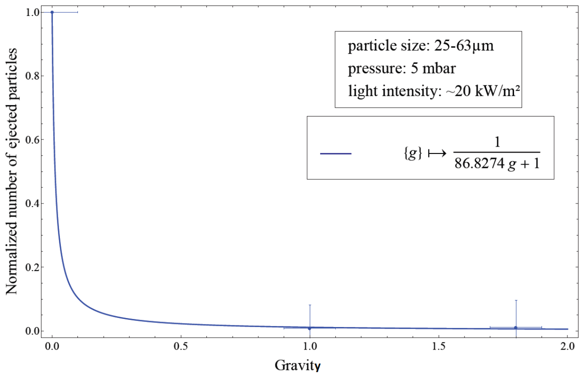

Figure 3: Example: Normalized number of ejected particles over gravity.

2. Application

In general wind speeds on Mars seem to be to low to lift dust by gas drag alone at ambient pressures of some mbar [2, 5]. However, dust phenomena like dust storms or dust devils are commonly observed on Mars. Even at higher elevations of several km – like inactive volcanoes – where the ambient pressure is reduced to ~ 1 mbar active dust devils are observed. At such low pressures even higher wind speeds would be needed for dust lift. Our experiments showed that light induced particle ejections are more massive at reduced gravity (Mars: 0.38g) and work best at pressures of some mbar. We suggest that dust phenomena on Mars might be triggerd by light induce particle ejections. At least photophoretic ejections support other dust lifting processes. The results of our present and upcoming 0g experiments on particle ejections indicate that the light induced ejection mechanism is a key process to understand the dust lifting on Mars.

3. Summary and Conclusions

Our experiments showed that light induced particle ejections caused by a solid state greenhouse effect and photophoresis might play key role in dust lifting processes on Mars. We found that the particle ejections are strongly g-dependent and follow a $1/g$ law. The 0g experiments help to understand the effeciency of this special erosion mechanism on bodies with reduced gravity like e.g. Mars (0.38g) but also planetesimals (μg). Especially on Mars the light induced particle ejections might shed some light on the until to date not fully understood problem of how dust particles can be lifted from the martian surface into the atmosphere by e.g. dust storms and dust devils [1]. Additional experiments in June 2011 with 0.18g (Moon conditions) and 0.38g (exact Mars conditions) will complement our results.

Acknowledgements

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References

[1] J. A. Fisher, M. I. Richardson, C. E. Newman, M. A. Szwast, C. Graf, S. Basu, S. P. Ewald, A. D. Toigo, and R. J. Wilson. A survey of Martian dust devil activity using Mars Global Surveyor Mars Orbiter Camera images. *Journal of Geophysical Research (Planets)*, 110:E03004, March 2005.

[2] R. Greeley, R. Leach, B. White, J. Iversen, and J. B. Pollack. Threshold windspeeds for sand on Mars - Wind tunnel simulations. *Geophysical Research Letters*, 7:121–124, February 1980.

[3] T. Kelling, G. Wurm, M. Kocifaj, J. Klačka, and D. Reiss. Dust ejection from planetary bodies by temperature gradients: Laboratory experiments. *Icarus*, 212:935–940, April 2011.

[4] M. Kocifaj, J. Klačka, G. Wurm, T. Kelling, and I. Kohút. Dust ejection from (pre-)planetary bodies by temperature gradients: radiative and heat transfer. *Monthly Notices of the Royal Astronomical Society*, 404:1512–1518, May 2010.

[5] C. Stanzel, M. Pätzold, D. A. Williams, P. L. Whelley, R. Greeley, G. Neukum, and The HRSC Co-Investigator Team. Dust devil speeds, directions of motion and general characteristics observed by the Mars Express High Resolution Stereo Camera. *Icarus*, 197:39–51, September 2008.

[6] G. Wurm and O. Krauss. Dust Eruptions by Photophoresis and Solid State Greenhouse Effects. *Physical Review Letters*, 96(13):134301–+, April 2006.

[7] G. Wurm, J. Teiser, and D. Reiss. Greenhouse and thermophoretic effects in dust layers: The missing link for lifting of dust on Mars. *Geophysical Research Letters*, 1(1):1–1, 2008.