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# Investigation of the solar influence on clean and dusty $CO_2$-ice under Martian conditions

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## Abstract

$CO_2$ is the main component of the Martian atmosphere. Therefore the polar caps are – depending on hemisphere and season - partially or totally covered with $CO_2$-ice. In contrast to rock and soil surface layers, which absorb and reflect incoming solar radiation immediately at the surface, ices are partially transparent in the visible spectral range, while they are opaque in the infrared. These properties are responsible for the so-called "Solid–State Greenhouse Effect" (SSGE). The SSGE may have a major influence on the sublimation and re-condensation of $CO_2$ and its circulation in the Martian atmosphere. Our work will concentrate on the influence of the SSGE on $CO_2$-ice under Martian like conditions.

## 1. Introduction

The planetary atmospheric greenhouse effect and the temperature increase connected to it is a well-known phenomenon. Less known is that a similar effect takes place in solid translucent objects like ice. The solid-state greenhouse effect can lead to an increase in subsurface temperatures because low-albedo particles embedded in the ice absorb energy across the entire solar spectrum and radiate in the infrared. The SSGE has implications for many planetary processes. For example, a subsurface temperature increase is a possible scenario for the formation of the so-called Martian spiders [1]. One hypothesis regarding the formation of these spiders is that they form through the channelling of $CO_2$ gas sublimed from beneath the transparent seasonal ice [2]. The subsurface temperature evolution leading to the temperature maximum below the surface as described above is not limited to $CO_2$; over different spatial scales, it can be observed in all transparent or translucent ices and may result in cavities being filled with liquid or gas.

Our experiments at The Open University's Planetary Ices Laboratory focus on the SSGE in $CO_2$ ice where we are building on past experiments performed at the Space Research Institute in Graz with the main focus on layered samples with a covering coat consisting of pure $H_2O$-ice (see [3]). The first results of measurements in $CO_2$-ice will be shown and possible implications for the understanding of various phenomena observed in the Mars polar areas will be discussed.

## 2. Laboratory experiments

The experiments were conducted in an environmental chamber that can be evacuated to a pressure of $<10^{-5}$ mbar and cooled down to 80 K. Radiation intensities corresponding to solar distances from 1 to 2 AU can be achieved with a solar-simulator. Our experiments have included measurements of the temperature profile in $CO_2$ snow, in transparent $CO_2$ ice and in transparent $CO_2$ ice with a layer of JSC MARS-1A dust.


Figure 1: Laboratory set-up: Solar simulator (left), vacuum chamber (right), $LN_2$ dewar (front).

## 3. First results

The series of test was started with several runs using $CO_2$ snow as sample material. During each test the temperature profile inside the block was measured with PT100 sensors while the sample was irradiated with artificial solar light with a power of about 650 $Wm^{-2}$ at a pressure of 5.7 mbar ± 0.25 mbar. The measured temperature profile of the snow samples, as shown in Figure 2, showed no clear sign of an internal temperature maximum – a result that was not unexpected since snow has a very high albedo and only a small part of the irradiation is absorbed by the sample. Furthermore, one has to bear in mind that there is a volume loss during the irradiation phase and therefore not all sensors show the temperature inside the sample for the entire duration of the test.

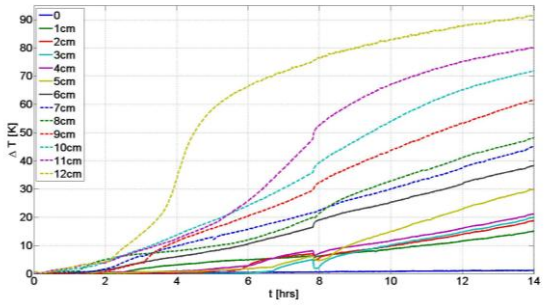


Figure 2: Temperature profile of a $CO_2$ snow sample at Martian pressure irradiated with 650 $Wm^{-2}$.

First tests with blocks of clear $CO_2$-ice show - in some cases - higher temperatures deeper inside the block than closer to the surface. Moreover, first tests with a block of $CO_2$-ice that included a dust layer were carried out. We found that temperature increases inside the sample were linked to the ambient pressure.

## 4. Summary

We could not find any experimental evidence for the relevance of the SSGE in pure $CO_2$ snow/ice. However, our experiments show an influence on the temperature profile if the ice includes a dust layer. In order to obtain reproducible results, further tests with an improved set-up are required.

## Acknowledgements

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## References

[1] Portyankina, G., and Markiewicz, W.J.: Model for the formation of spider patterns in the cryptic region, 3rd International Conference on Mars Polar Science and Exploration, Alberta, Canada, abstract no. 8026, 2003.

[2] Kieffer, H.H.: Annual punctuated CO2 slab-ice and jets on Mars, 2nd International Conference on Mars Polar Science and Exploration, Univ. of Iceland, Reykjavik, 21–25 Aug. 2000.

[3] Kaufmann, E. et al.: Laboratory simulation experiments on the solid-state greenhouse effect in planetary ices, Icarus, 185, 274-286, 2006.