COMPARISON OF SPACE WEATHERING SPECTRAL CHANGES INDUCED BY SOLAR WIND AND MICROMETEOROID IMPACTS.
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Introduction: Space weathering causes changes of airless planetary bodies' surfaces. As a result, the spectral features of the bodies evolve. Visible and near-infrared spectra of dry silicate bodies darken, their spectral slopes increases and their diagnostic mineral absorption bands get less intense [1], [2], [3].

The changes are caused mainly by the effects of solar wind ions and by the impacts of micrometeoroids [1]. In our research, we focused on what is the difference between the spectral evolution due to ion irradiation and due to micrometeoroid impacts (realized by individual femtosecond laser pulses).

Methods: We have done four different types of irradiations of olivine and pyroxene pellets. To simulate the silicate surface of different ages subject to the solar wind, we have used ions of hydrogen (5 keV), helium (20 keV), and argon (40 keV) of different fluencies, up to 10^{18} ions/cm^2. These experiments were done using the INGMAR setup interfaced to the SIDONIE implanter, IAS-CSNSM, Orsay and at the Helsinki Accelerator Laboratory.

To simulate micrometeoroid impacts, we have shot individual 100-fs laser pulses into a square grid (similar to [4]). The increasing age of the surface was realized by a higher density of pulses. We have reached a maximum density of one pulse every 10 μm. These irradiations were done at the Department of Chemical Physics and Optics, Charles University.

After the irradiations, we have always measured the spectra and afterwards analysed them. Except for the direct comparison of the spectral curves, we have also compared the evolutions of the individual spectral parameters obtained using the Modified Gaussian Model [5] [6] and plotted the spectra in the principal component space. Additionally, we have plotted the spectra of the silicate-rich asteroids from the DeMeo's database [7] into the principal component space of our spectra, to obtain a comparison of the weathering evolution of our samples and the real solar system bodies.

Results: The spectral changes caused by individual irradiations are similar to the previous works concentrating onto the same type of effect. By comparing the ion and laser irradiation, we have noticed several things:

Mineralogy vs space weathering. Based on the trends we have obtained, the way the spectra will evolve is more dependent on the original mineralogy of the sample than on the space weathering agent. The most significant difference between the olivine and pyroxene trends has been found in the evolution of the spectral slope. Olivine showed significant reddening of the spectral slope, while pyroxene's spectral slope changed only little.

Long wavelengths differences: The greatest difference between the ion and laser irradiations was observed at long wavelength (around 2–3 μm). Laser irradiation caused significant changes to this wavelength range. On the other hand, all the ions affected the long wavelengths only mildly. See Fig. 1 for an example.

This behavior has great consequences in the understanding of the differences in the spectral slope evolution due to solar wind irradiation and micrometeoroid impacts. The difference between the two types of irradiation is probably connected to the different penetration depth of ions and laser pulses.

Asteroids' implications: Based on the evolutions of individual spectral parameters we can make conclusions relevant to some types of asteroids. We are for example able to explain why do the A-type asteroids have mostly high slopes. We also see why the asteroid (4) Vesta does not show significant changes of the spectral slope while manifesting pronounced albedo changes.

Conclusions: Our results show that the initial mineralogy of the surface is more determinative to the spectral evolution than the space weathering agent. Still, there is a difference between the impact of the ions of the solar wind and of the micrometeoroid impacts (simulated by laser pulses) on longer near-infrared wavelengths. Which may enable us to evaluate surface exposure ages of different geomorphological features in the solar system bodies.

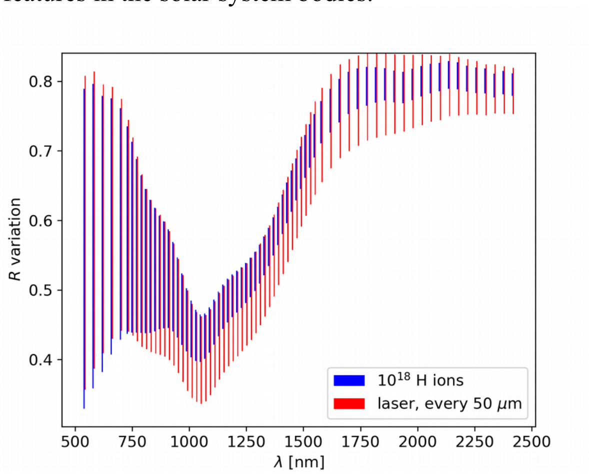

Figure 1: Difference between the reflectance, *R*, variation due to laser and ion irradiation. Top ends of the bars mark the fresh material reflectance, the bottom ends mark the irradiated material reflectance.

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