PLANETARY SCIENCE EDUCATION I. COMPARISON OF HALO RINGS PRODUCED BY ELECTROMAGNETIC WAVES SCATTERED THROUGH THE CLOUD OF RANDOMLY ORIENTED MACRO AND MICRO CRYSTALS (IN THE ICE CLOUD AND IN THE DUST). ***Ságodi I.*** [1]***, Bérczi Sz.*** [2]. [1]*Szekszárdi Garay János High School, H-7100 Szekszárd, Szent István tér 7-9. Hungary, (sagodi62@freemail.hu)* [2]*Eötvös University, Faculty of Science, Dept. of Materials Physics, Cosmic Materials Space Res. Group, 1117 Budapest, Pázmány P. s. 1/a. Hungary, (bercziszani@caesar.elte.hu)*

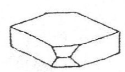
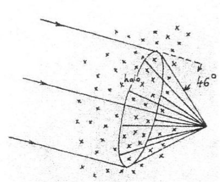
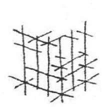
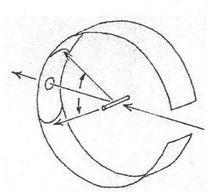
Introduction

Planetary geology often uses the comparative method. It compares the surface phenomena on the solar system's planets with the corresponding terrain (comparative planetology). In this paper we apply this comparative method in two different material system measuring fields of planetary physics. Two well known phenomena and their measuring principles are compared: the atmospheric ringed halo phenomenon and the Debye-Scherrer method of Röntgen-crystallography. We will present them in a common frame of thought, because these two seemingly remote group of phenomena and measurements are linked by several decisive conditions.

Common features

Three basically common features are found for these two phenomena and study. The first common feature is that crystals are present in the space, in large numbers and in disordered and randomly oriented form. Another common feature for them is that the cloud of randomly oriented crystals interacts with one electromagnetic wave form. The third common point is that light interacts with the crystals and by means of interaction, "selects" the crystals that form a ring pattern at a particular point (observer, sensor streak) of the space. As a summary: Common features are: 1. The randomly oriented crystal set, 2. interaction with and EM wave, 3. selection into a ring pattern.

Summarizing table:

Structural Hierarchy level	The drawing of the phanomenon	Great number of crystals are present	Wave-length of the interacting wave	The physical phenomenon	The image (ring) produced by the interaction
Crystal form 	Visible light, halo-ring in atmosphere 	Freely levitating crystal particles	Visible light (between c.a. 400-700 nm wave-lengths)	Refraction in the individual crystals	Halo ring on the sky around the light source
Crystal lettice 	XRD, X-ray, Debye-Scherrer halo 	Crystal particles relying on aech other, inside crystals suitable lattice planes occur	X-ray with c.a. 0.1 nm wave-length	Interference ont he various lattice planes according to the Bragg equation	Debye-Scherer interference rings ont he sensor streaks

Different characteristics

a) Atmospheric halo phenomenon:

The material of the crystals is ice (in Earth: water ice). The ice crystals are levitating in the space, far away from each other. The interaction of the phenomenon is the refraction of the light in the crystals. The beam passing through a large number of crystals, at the moment of observation, guides the observed light beams from the individual crystals of the cloud to the eyes of the observer from a ring-like region.

b) The Debye-Scherrer study:
The crystal particles in the dust sample are the objects of measurement. (Any crystalline material is suitable to this measurement.) The particles of the dust sample rely on each other. The phenomenon is created by the interaction of the X-ray on the suitable grid planes of the crystal. This interaction is the interference with the crystal lattices of the crystal. The used X-ray is aligned with the grid plane distance of the crystal to be measured, according to the Bragg equation: ($n\lambda = 2d\sin\Theta$) where λ = wavelength, d = lattice plane distance, Θ = deviation angle). The lattice planes in appropriate positions give rise to the observable (XRD measurement) ring.

Special features in the two different phenomena:
Over the common and distinctive features there are special features of the measurements of the different two phenomena, as follows. In the case of the atmospheric halo-rings both the observer and the crystal particles in the cloud can move, but the halo-ring has an essentially the same position. Due to the large number of ice crystals, there will always be a sufficient number of refractive crystalline grains to provide a ring effect for the observer.

It is an important distinction that the ring-forming phenomenon in the case of ice crystals is the optical refraction in the crystal particle itself. In the case of the XRD measurements the material treated in the study is the (powder-crushed) material of the crystalline particles, the phenomenon being caused by the interference of the X-ray light on the plane of the crystal lattice. The phenomenon of the XRD is a phenomenon of a deeper hierarchy level, than crystal: not the crystal itself, but its subsystems, the lattice planes are the ring forming units.

Summary:

An interesting chapter of measurements of planetary materials has been presented. The program was: How to teach measuring of two related phenomena by comparing their complex background. The atmospheric halo-rings and the X-ray rings (in XRD) by crystallographic interference from the Debye-Scherrer method: origin in different electromagnetic wave ranges. However, in one case, the refraction (atmospheric halo), and the other, the interference (XRD), results in the same phenomenon: the ring, produced by their randomly arranged crystal sets. From the randomly arranged crystal set, only the suitable ones contribute to the ring-imaging effect. The students were impressed by the idea of connecting the two remote phenomena. By teaching the two phenomena separately, they miss the benefits of understanding the complex phenomenon while simultaneously teaching and comparing the two phenomena reveals these connections. [1-4]

References:

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