Opponent Report on the doctoral thesis by Katerina Chrbolková:

EVOLUTION OF SPACE WEATHERING AND ITS COMPONENTS - EFFECT OF SOLAR WIND AND MICROIMPACTS ON REFLECTANCE SPECTRA OF AIRLESS PLANETARY SURFACES

The dissertation of Katerina (Chrbolková) Flanderova presents a thorough discussion of the importance of space weathering effects on asteroids, including theory and laboratory work to investigate effects. This work represents new, important information on these topics, that will contribute greatly to the literature and the community.

Ground-based reflectance spectroscopy of asteroids represents one of the only techniques by which we can currently aim to understand these important building blocks of the early solar system. Relatively very few spacecraft have visited asteroids, to provide disk-resolved measurements. We have returned samples from a handful of asteroids, and meteorites to study in the laboratory, from mostly unknown parent bodies. Thus, though limited in spatial resolution - and to some extent in spectral coverage - ground-based reflectance spectroscopy has been the primary technique for gaining compositional information about these important targets. And yet, these bodies' spectra are affected by space weathering processes, namely bombardment by micrometeoroids and solar wind particles, which can confound our understanding of their surface compositions. Thus, the scientific significance of Katerina's topics of research ultimately links to the questions: how do we understand the Moon and its surface processing, and how can we use that ground truth to then understand these abundant small bodies that are remnants of the early solar system, to learn about our solar system origins and evolution?

Chrbolková's thesis presents a comprehensive overview of the processes involved in space weathering and previous attempts to understand the effects, via laboratory measurements, along with the open questions. Her thesis demonstrates a strong understanding of the basics of reflectance spectroscopy for some minerals important for characterizing the Moon and some types of asteroids, and the thesis is presented clearly and in a very readable style. Chrbolková understandably sets boundaries to her work (e.g. focusing on olivine and pyroxene for minerals, and on micrometeoroid and solar wind particle bombardment for space weathering processes) and provides strong justification for her choices.

In her initial study, Katerina chose to study lunar swirls as a technique for probing space weathering effects, given that swirls may be magnetically shielded from solar wind bombardment; she points out, however, that swirls are expected to be old enough that micrometeoroid bombardment should have had a spectral or albedo effect if this process is a strong player in producing space weathering effects, and she ultimately suggests that micrometeoroids alone do not induce the complex range of spectral changes that are likely produced by the solar wind. She found that laboratory work would be required to study potential effects of both solar wind and micrometeoroid space weathering. Impressively, Katerina worked with three different laboratoriess in order to accomplish a wide range of simulations, including proton irradiation, helium and argon ion irradiation, and laser irradiation.

As her opponent at the public defense, I took it upon myself to query the candidate's background knowledge and understanding of new works in the literature and their implications for her work, and also encouraged the candidate to "think outside the box" and attempt to extend the insights she had gained through her thesis work to additional applications. At the defense, I found that Katerina was familiar with nearly all of the recent publications about which I asked her, and had considered them enough that she was prepared to discuss her own results in the context of other new results. She demonstrated significant fluency in the topics of her realm of study. I thus found this candidate to be very familiar with her very broad field of research - including the study of asteroids, space weathering and the relevant laboratory experiments and measurements. I pressed the candidate on several issues, to engage her in debate. For instance, I encourageed her to discuss the possible implications of her work on near-Earth asteroids and even icy moons. I was also impressed with her explanation of the need to do further work including laboratory experiments, in order to delve more deeply into the questions that she was addressing, especially given that she found that the study of lunar swirls produced interesting and important, though perhaps somewhat limited, results. I also found it remarkable that she took it upon herself to expand her circle to include new colleagues with whom she could undertake the additional laboratory studies that she found she required in order to address her science questions.

In her oral defense, Katerina demonstrated that she understands and is well-aware of the possible thermal emission contamination in the M^3 dataset and assured me that her work focused on wavelengths less impacted by those effects. I found that Katerina was knowledgeable about and aware of the possible implications of atmospheric contamination on her laboratory samples, and the possible effects of Earth's gravity in attempting to study powders analogous to lunar or asteroidal regoliths, in the laboratory setting. We discussed rather extensively her choice, and the necessity, from a logistical standpoint, to use powders of a particular grain size pressed into pellets, and the pros and cons of doing so when comparing to surfaces with loose regoliths.

We also discussed her use of visible-near infrared (and mid-infrared) wavelengths, and possible implications of her result that the shortest wavelengths (visible) appear to be most sensitive to small amounts of weathering. She agreed that this is consistent with previous results showing that even shorter, ultraviolet, wavelengths are very sensitive to small levels of weathering, perhaps due to the relatively shallow penetration depths.

Overall, my conclusion is that Katerina's written thesis represents excellent work that contributes significant insights into the field; furthermore, her command of the information, as expressed during her oral defense, demonstrated a strong familiarity with, and expertise in, the subjects and insights that allowed her to engage in debate and discussion on various facets of her work. Katerina's thesis work is of great significance for the fields of lunar and asteroid science, as well as for advancing our understanding of the utility of various laboratory techniques for studying solar system processes. She is to be commended for her wide-ranging, excellent command of knowledge in these areas, as demonstrated through her written work and through her oral defense.

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