The Need for Mineral Physics in Exoplanetary Science

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Terrestrial exoplanets represent a new frontier in Earth science. From the discovery of sub-Mercury and super-Earth planets to the potential for magma- and water-ocean worlds, these planets are unlike anything seen in our Solar System. Furthermore, stellar observations show variations in the abundances of the major (Mg, Fe and Si) and minor (Al, Ca, Na) terrestrial planet-building elements between 10 and 400% of the Earth and Solar values. As we seek to understand the mineralogy, structure, transport of volatiles and potential habitability of these terrestrial planets, combining this compositional diversity with the expected wide range of pressures and temperatures in exoplanet interiors is of paramount importance. Currently, however, the majority of both equation-of-state and phase equilibria studies available to exoplanet researchers were undertaken to solve problems across the pressure, temperature and compositional scope of the Earth and our Solar System. These results are often extrapolated by exoplanetary scientists well beyond this range and used to infer the likely composition of specific exoplanet systems.

This extrapolatory approach is fraught with pitfalls. The specifics and nuances of these hazards are often only known within the mineral physics community due to a lack of communication between the Astronomy, Planetary Science and Earth Science fields. In this presentation I will highlight the need for these communication channels as well as many of the experimental and modeling opportunities for mineral physics currently needed to solve many problems in exoplanetary science. Examples include the mantle mineral assemblages of non-Earth compositions and their variable melting, elastic, viscous and volatile storage properties, the behavior of iron under super-Earth pressures and temperatures, and the need for easy-to-use open source software for use across disciplines.