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Can Impact-generated Plasmas be Responsible for Magnetization on Moon?

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Although the Moon presently does not have a core dynamo magnetic field, spacecraft measurements have revealed the presence of remanent magnetization in the lunar crust. The source of the crustal magnetic anomalies remains uncertain. A key question is whether the crustal magnetization is a record of ancient intrinsic fields, or whether they were created by external fields. In the latter case, an ancient dynamo field is not needed in order to explain the anomalies. This carries broad implications to our understanding of the Moon's thermal history and current internal structure. Furthermore, the lunar crustal field serves as a test case for understanding magnetization of other solar system bodies, such as Mars, Mercury, and asteroids.

Strong anomalies were identified at the antipodes of young large impact craters, which has led to the theory that meteor impacts may be responsible for the magnetization of the crust. In this picture ionized vapor clouds, generated by the impacts, interact and compress the surrounding solar wind. These transient field amplifications would subsequently be recorded by heated or shocked lunar rocks.
Although this hypothesis has been studied for several decades using hydrodynamic and impact simulations, all simulations thus far did not include the magnetic field, and magnetic field amplification was only estimated from general geometric arguments. To address this gap, we coducted the first magnetohydrodynamic simulations of this process. We systematically explore the role of magnetic field reconnection, variable solar wind conditions, friction between the vapor and molten ejecta, and the finite resistivity of the lunar mantle and crust. Our preliminary results show that vapor expansion and magnetic field reconnection would cause large amounts of solar wind magnetic flux to be removed, leading to only moderate field amplification at the antipodes, several orders of magnitude below the required value. We propose that the compression of the solar wind magnetic field following impacts is probably not the cause of magnetization on the lunar crust, and that the source of magnetization is more likely to have been an internal core dynamo. This implies that the Moon formed an advecting metallic core in its early history.