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Formation Models of Planet Mercury

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Mercury is an end member planet due to its close proximity to the Sun. In comparison to orbits of extrasolar Jupiter-sized planets, our Solar System seems to exhibit a rather unique constellation: Jupiter is far away from the Sun to allow stabile orbits of several terrestrial planets within its orbit. Mercury, the most extreme planet, is a distinctive witness of the conditions of the early Solar System.

Besides position and rotation of Mercury, its mean density of 5.3 g/cm3 is one of the most remarkable features: Mercury is too heavy compared to the volume of other terrestrial planets. Any model to explain origin and evolution of Mercury must account for its unusually high density.

In general, one can assume that Mercury contains a large core (metallic phase) and a relatively thin mantle (silicate phase) resulting in twice the Fe/Si bulk ratio compared to the other terrestrial planets. One model assumes for the solar nebular that the feeding zone of the proto planet Mercury was enriched in Fe resulting in a highly increased Fe/Si ratio compared to other terrestrial planets. A second model speculates that in the close proximity of the sun the conditions were highly reducing so that other elements like silicon would occur in metallic form and, hence, contribute to the metallic core.

The accretion of most of the terrestrial planets can be assumed by mixing two different components (reduced and oxidized) of the solar nebular in different ratios. Mercury would have received more than 90 % of the reduced component resulting in a highly reduced planet. In contrast, Mercury could have experienced a normal accretion with core formation. A giant impact by a Mars-sized body vaporized and ejected large portions of the mantle (separation of Fe & Si) resulting in a large core surrounded by a thin mantle. Or Mercury accreted as a normal planet, but, the interactions of a very hot solar nebular wind with its surface caused vaporization of thick layers of rocks. Other scenarios highlight the loss of volatile material due to high temperatures during the early Solar System.

Spacecraft driven investigations of the Hermian surface will shed light on origin and evolution of Mercury and in consequence on the formation of the Solar System. To achieve discrimination between the different evolution models the determination of the elemental composition of Mercury's surface will be a crucial task. Orbital gamma-ray and x-ray spectroscopy of the Hermian surface will provide significant data that can be used to solve the puzzle of Mercury's high density.