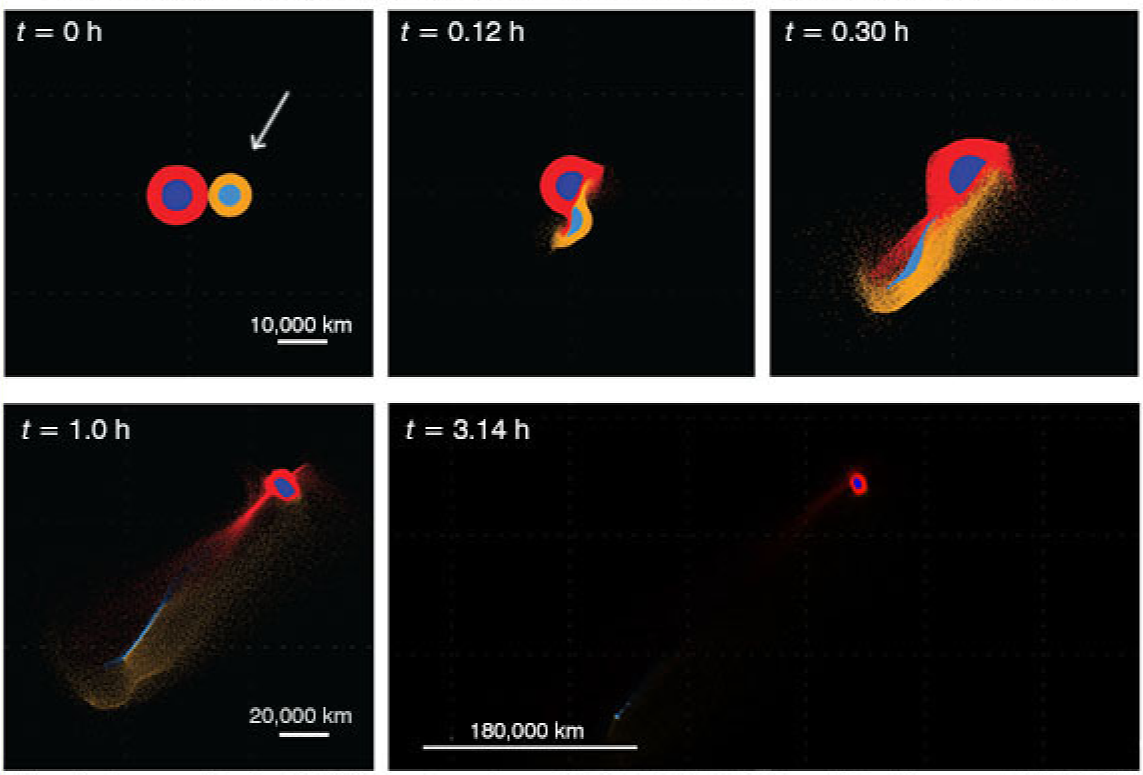
Invoking a Hit-and-Run Collisional Origin for Planet Mercury

The chaotic disruption of colliding planetesimals during glancing, hit-and-run collisions is a well known idea in cosmochemical circles. See PSRD articles covering dynamical models of hit-and-run collisions: ***Formation of Stony-Iron Meteorites in Early Giant Impacts***, ***When Worlds Really Did Collide***, ***Hit-and-Run As Planets Formed***, and the almost hit-and-run collision of the giant impact hypothesis for the ***Origin of the Earth and Moon***. Grazing collisions between proto-Mercury and a larger body have been modeled to explain Mercury's massive metallic core and thin rocky mantle. Continuing this work, Erik Asphaug (Arizona State University) and Andreas Reufer (ASU and University of Bern, Switzerland) applied numerical models to the formation of Mercury to explain the planet's non-chondritic, high metallic iron content (about 70% by mass) and high volatile content (as revealed by MESSENGER data).

Simulation of a Hit-and-Run Collisional Origin for Planet Mercury



(From Asphaug and Reufer, 2014, *Nature Geoscience*, doi: 10.1038/NGEO2189 and http://vimeo.com/77504026.)

Five time steps (upper left to lower right) in a numerical simulation of a hit-and-run collision reported by Asphaug and Reufer. The arrow shows direction of the projectile with about one-third the target's mass. Blues indicate the metallic iron cores; red and gold indicate silicate mantles of the bodies. In this model, a differentiated chondritic proto-Mercury (the smaller blue and gold sphere) has its mantle stripped off in a grazing collision with a more massive proto-Venus or proto-Earth (blue and red sphere). Watch Andreas Reufer's video of the simulation here: ***vimeo.com/77504026***.

Using the Smoothed Particle Hydrodynamics code, Asphaug and Reufer tested different impactor/target mass ratios, impact velocities, and impact angles to find hit-and-run collision scenarios that form a planet consistent with Mercury's volatile and metal content, see figure above. The larger target body survives. In one or two hit-and-run collisions, the shattered projectile avoids being accreted into the target body but looses its mantle silicates—these dispursed silicates ultimately become part of the target body. The metallic debris re-accretes. In Asphaug and Reufer's scenario, if proto-Mercury were such a projectile, then the leftover metallic debris re-accretes into a growing Mercury and the stripped mantle silicates are incorporated into the target (proto-Earth or proto-Venus). "The implication of the dynamical scenario explains, at long last, where the 'missing mantle' of Mercury is — it's on Venus or the Earth, the hit-and-run targets that won the sweep-up," says Asphaug (***read the entire news release*** from Arizona State University).

See Reference:
· Asphaug, E. and Reufer, A. (2014) Mercury and Other Iron-rich Planetary Bodies as Relics of Inefficient Accretion, *Nature Geoscience,* published online July 6, 2014, doi: 10.1038/ngeo2189. [***abstract***]

See also:
· ***Video showing the simulation of a hypothetical Mercury-forming hit and run collision***, computation by A. Reufer (ASU/U. Bern).
· ***Planet Mercury a Result of Early Hit-and-Run Collisions*** press release written by Nikki Cassis, Arizona State University.

· ***Planetary Smashup Left Mercury with a Massive, Metallic Heart*** written by Nadia Drake, Phenomena: No Place Like Home, hosted by National Geographic Magazine.

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