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The magnetic dichotomy of the Galilean satellites Europa and Ganymede

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One of the most surprising discoveries of the Galileo mission was the detection of a self- generated magnetic field in the vicinity of Ganymede. Up to that discovery, it was widely believed that Ganymede did not fully differentiate and had a central region composed of silicates and iron and an outer ice layer. The existence of the self-generated magnetic field together with the relatively small value of the moment-of-inertia factor, suggests that Ganymede is strongly differentiated into an iron core, a silicate mantle and an outer ice layer. Based on Galileo gravity field measurements, a similar interior structure has been proposed for Europa where an internal magnetic field is absent.

It has been suggested that chemical convection due to the precipitation of iron or iron sulfide is the most likely mechanism to power a present-day dynamo on Ganymede. Chemical convection and dynamo action will start as soon as core temperatures fall below the liquidus temperature of the core alloy and operates as long as the core is cooling. Interestingly, although Ganymede is about 700 km larger in radius than Europa, the differences in size and mass of the silicate and iron part, respectively, are only small for both satellites. As a consequence, one would expect a similar thermal and magnetic field evolution in both cases. However, thermal evolution models indicate that it is even more likely for Europa to generate an internal field if the same set of parameter values for mantle rheology and radioactive heat source density is used as for Ganymede.

We will discuss two scenarios that may help explain the puzzling magnetic dichotomy between both satellites: (1) a larger content of light elements in the core of Europa as compared to Ganymede and (2) tidal heating in the silicate mantle of Europa.