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A dynamo model for Ganymede

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Ganymede's internal magnetic field is most probably generated by a dynamo in a relatively sulphur-rich iron core, which has 1/4 to 1/3 of the planet's radius. The field is dominated by the axial dipole. The quadrupole component appears to be very weak. The ratio of quadrupole power to dipole power, measured at the top of the core, is R2/R1 < 0.04, which is the lowest ratio of all planetary dynamos in the solar system. Crystallization of iron in Ganymede's core likely proceeds top-down, with iron snow forming in a layer near the top of the core. The layer becomes stably stratified because a strong gradient gradient in sulphur concentration. In the case of very high sulphur concentration, a conducting solid FeS layer would form above the liquid core. We model either one scenario by a numerical dynamo model driven by a compositional flux at its outer surface. The dynamo region is overlain by a stagnant conducting shell. We vary the Rayleigh number, Ekman number and magnetic Prandtl number and compare in each case models with and without conducting outer shell. Depending on parameter values, we find dipole-dominated fields or hemispherical magnetic fields. For the dipolar dynamos the time-average ratio R2/R1 is in the range 0.02 - 0.20 without conducting shell. With a shell with a thickness of 1/6 of the core radius and equal conductivity, R2/R1 is reduced by a factor of typically four. Also if the shell thickness or its conductivity is reduced by a factor of one half, R2/R1 is always found to be less than 0.03, in agreement with the available evidence at Ganymede. For plausible values of the buoyancy flux in Ganymede's core, the models predict a dipole moment of the correct order.