FORMATION OF THE GIANT PLANETS

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The structure of a gaseous envelope surrounding a icy/rocky core is studied in consideration of radiative transfer. It is found that when the core grows beyond a critical core mass, the envelope cannot be in equilibrium and collapses onto the core to form a proto-giant planet. The results are as follows (for details, see Mizuno 1980).
1) The critical core mass is smaller than that estimated by Perri and Cameron (1974) and Mizuno, Nakazawa and Hayashi (1978). 2) When the grain opacity in the envelope varies from 0 to 1 cm^2/g, the critical core mass changes from ~2 to ~12 Earth's masses. 3) The critical core mass is independent of the region in the solar nebula.
These are due to the existence of the radiative region in the envelope.

Result 3) is consistent with the recent theory of the structure of the giant planets that they have the common core masses (Slattery 1977; Hubbard and MacFarlane 1980). Also it is seen from result 2) that the terrestrial planets did not become the giant planets.

REFERENCES

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DISCUSSION

Bodenheimer: What is the physical mechanism for the collapse of the envelope in your models?

Mizuno: Here, collapse means that there is no equilibrium configuration.

Bodenheimer: Why shouldn't the core mass continue to grow by accretion of planetesimals even after the critical core mass is reached?

D. Sugimoto, D. Q. Lamb, and D. N. Schramm (eds.), Fundamental Problems in the Theory of Stellar Evolution, 133–134.

Mizuno: If the escape of the solar nebula occurs soon after the collapse of the envelope, the core mass does not increase very much over the critical value.

Tscharnuter: Shouldn't the giant planets spin up considerably during the collapse of the envelope, since they separate from a differentially rotating nebula?

Mizuno: The angular velocity of the inner region of the envelope, where almost all of the envelope mass is contained, is very small compared with the Keplerian angular velocity at the boundary of the core.

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