COMET FORMATION INDUCED BY THE SOLAR WIND

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ABSTRACT

The current evidence concerning the nature of comet nuclei suggests that comets may be sizeable aggregations of interstellar grains. This is a progress report on an effort to find circumstances and processes whereby such aggregations might be formed in the solar system at distances far beyond the protoplanets during the early stages of solar-system development. Under investigation are interactions between the early solar "gale" and the surrounding interstellar gas and dust–the so-called "snowplow effect." Compression of the gas and resultant motions of the dust coupled with the pressure radiation from the Sun and nearby new stars may, under certain idealized circumstances, produce a high enough concentration of dust for gravitational instability to occur in the dust, thereby producing km-sized coherent bodies. The likelihood or probability of actual comet formation by such processes remain to be determined.

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DISCUSSION

J. C. Brandt: Dr. Whipple, do you have observational methods for out flows from solar type stars at rates 10^6 to 10^8 times the present solar wind?

F. L. Whipple: Kuhi's studies of the t-Tauri stars suggest 10^6 or 10^7 times the present solar wind.

Stephen Strom believes it. Strom even likes 10^6 solar masses per year of lose for the first 10^4 or 10^5 years.

There's a lot of difference of opinion on that. George Herbig here knows as much about it as anybody in the world, but he isn't saying a word, I notice.

J. C. Brandt: That number just strikes me as high.

F. L. Whipple: 10^{18} grams/sec would be a lot. That's about 10^6 times. 10^{20} gm/sec is 10^8 times. It strikes me as high, too.

M. Oppenheimer: Interstellar masses have been observed in the circumferential material about young stellar objects. These objects contain large densities of H_2O, OH, and CO which are species observed or searched for in comets, and other species, such as CH_3OH which may exist in comets. These species are efficient cooling agents through their molecular-transitions.

The maser regions are transitory phenomena which may rapidly cool and become thermally unstable through these molecular transitions. The cooled object less its H_2 molecules is of appropriate mass to become a comet. Thus, masers are associated with regions where Dr. Whipple says comets are forming. In fact, comets may actually be old masers which have cooled off and condensed.

W. F. Huebner: Regarding Prof. Whipples talk, I would like to point out that opacities used in the past for calculations of star formation (i.e., in gravitational collapse of interstellar clouds) are internally inconsistant. They are composits of certain approximations. For example, some average grain opacity has been used up to some temperature T_1, between this temperature and some temperature T_2 an average molecular opacity has been used, and beyond T_2 and average atomic opacity has been used. No effort has been made to allow for coexistence of several phases: there are no molecules below T_1, and no grains above T_1, nor is the composition of mantles on grains consistent with condensation

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of the molecular phase. It is very probable that the molecular opacities are too low because a number of molecular bands have been ignored. Just below T_1 and just above T_2 the opacity may be too low because molecules have been ignored in these regions. To give more quantitative estimates requires a detailed analysis. This is one of the problems we are working on.

F. L. Whipple: Just a quick comment on a very important problem.

In producing pseudo-gravity, one is interested in an actual true opacity; in other words, an absorption and re-radiation at longer wavelengths. Forward scattering doesn't help you much because if you forward scatter into the cloud, you don't get the pseudo-gravitation.

The general idea is that about half of the observed extinction is thought to come from absorption and re-radiation of long wavelengths. The other half is largely forward scattered and wouldn't affect it much.

So if the fraction is something like a half, I don't worry about it. That's much closer than the rest of the assumptions. But if it is one percent, then one would worry.

B. Donn: I would just like to repeat the comment Whipple made, that Herbig is staying very quiet through all of this.

(Laughter.)

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