I have this book if you would like to look at the original figures. -Elsie

3-D

Short Note: Snapshots from a Three-Dimensional Modeling of a Giant Impact

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We present results of a series of numerical simulations of an impact between the proto-Earth and an object of the size and mass of Mars (Benz *et al.*, 1985). The simulations were done using the "Smoothed Particle Hydrodynamic" (SPH) method (Gingold and Monaghan, 1982) using a total of 2048 particles.

The model includes self-gravity, shock heating, material under tension, and the possibility for material to be either vapor, liquid, or solid. However, to keep the problem tractable we did not include: shear strength (most of the simulations were started with molten planets), radiative transfer, or energy losses due to radiation (for timescale reasons). For convenience both planets were assumed to be made of granite (new models including iron cores are in progress). Finally, we modeled the thermodynamics using the Tillotson equation of state (Tillotson, 1962).

The simulations leading to the formation of a prelunar accretion disk of about 1 to 3 lunar masses and angular momentum corresponding to the Earth-Moon system are the ones started with a low relative velocity (less than 4 km/sec at infinity) and a large impact parameter. Starting with molten or solid planets does not make any difference. After the impact, part of the impactor forms a clump orbiting around the proto-Earth. This clump, however, is on a very eccentric orbit, bringing it back well inside the proto-Earth's Roche limit; it is therefore destroyed and spread out into a disk. It is worth noting that the material ending in the clump originates completely from the side of the impactor opposite to the proto-Earth at the time of the impact.

Figures 1 and 2 show snapshots of events taking place between the impact and the formation of a clump in orbit. Initial relative velocities at infinity are respectively

Fig. 1.

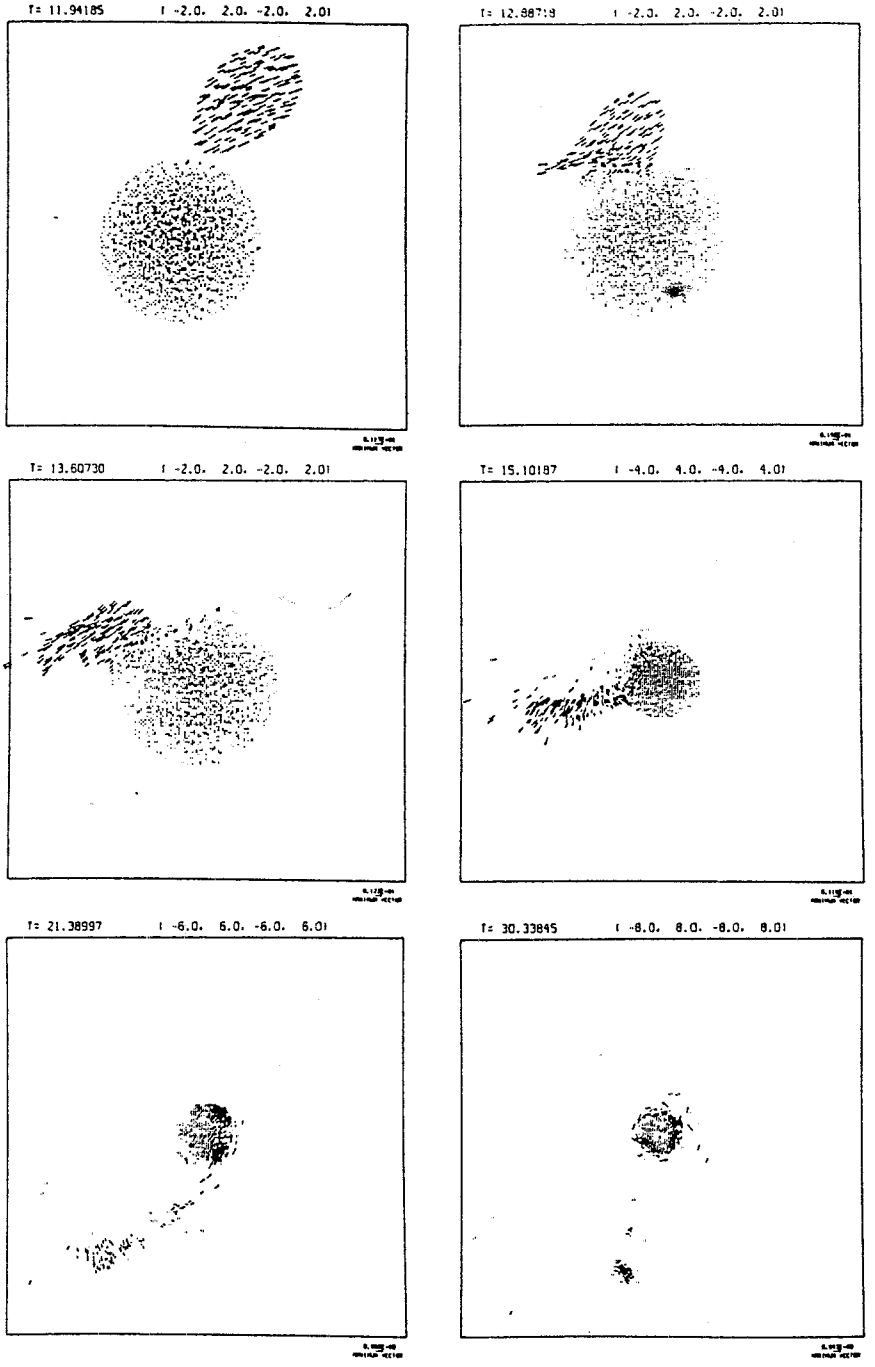
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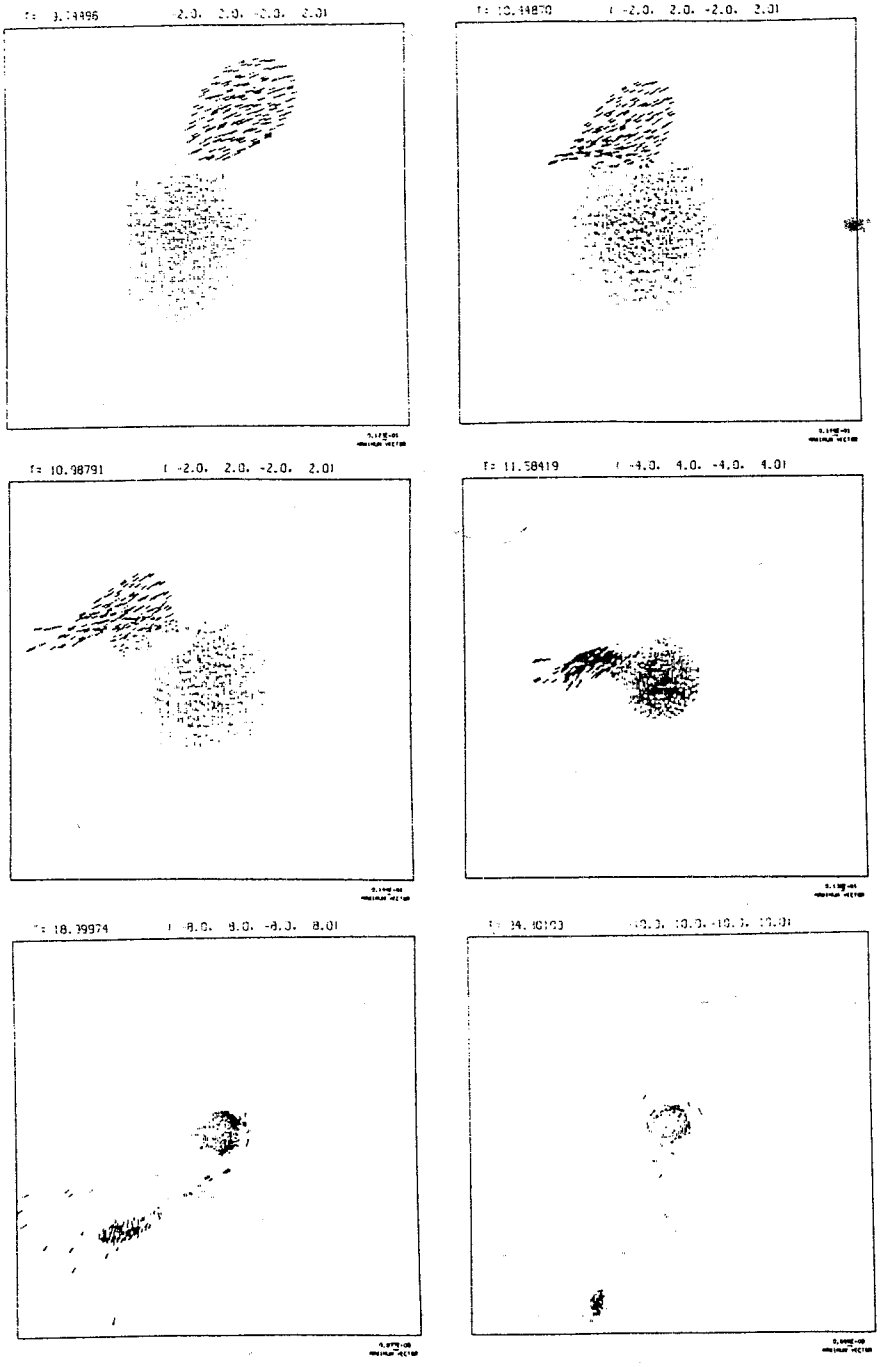
Fig. 2

Fig. 2.



0 km/sec (Fig. 1) and 3 km/sec (Fig. 2); all planets were considered as molten. The impact parameter in Fig. 2 is about 1.2 times larger than in Fig. 1. Plotted are velocity vectors at particle locations projected in the plane defined by the center of the two planets. Time is given in the upper line of each frame (1 time unit = 18.2 minutes). Note also the change of scale between frames. The coordinates of the four corners of the box are also given in the upper line (in units of 8008 km).

References

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Tillotson J. H. (1962) Metallic equation of state for hypervelocity impacts. *General Atomic Report GA3216*.