TIDAL DISRUPTION OF COMET SHOEMAKER-LEVY-9 NUCLEI JUST BEFORE THE IMPACT ON JUPITER; M. Yanagisawa and T. Konno, Univ. Electro-Communications, Chofu-shi, Tokyo, 182 JAPAN.

Each nucleus of Comet Shoemaker-Levy-9 (SL-9) will be disrupted due to Jovian tidal force just before its impact on the planet. The impact phenomena, for example, impact flash, significantly depend on whether fragments collide with the planet as a single pile or multiple impactors. We modelled the nucleus as being made of non-viscous fluid of 1 g/cm^3 in density and 1 km in diameter. We numerically simulated its tidal deformation during its approach to Jovian surface. The tidal force made the body spheroidal in shape but did not split it. The ratio of the major to minor axes of the spheroid has been shown to be 1.4 at the impact. The fragments of the tidally disrupted real nucleus will be confined in the spheroidal surface and not be scattered at the entry into Jovian atmosphere.

Introduction: SL-9 consists of about 20 nuclei. Its orbital parameters indicate that single cometary nucleus would split during its 1992 close approach to Jupiter due to the planet's tidal forces. Orbital calculations show that these nuclei will impact on Jupiter one after another in July 1994 [1]. If the tidal force exceeds the strength of the nuclei, each of them will be fragmented again and fragments may collide with the planet as multiple impactors. On the other hand, the fragments may play as a single body in the impact phenomena because there may not be enough time for them to be scattered before the impact. Whether the fragments act as a single or multiple impactors depends on how wide they are scattered. Simulated tidal deformation or disruption of a hypothetical strength-less object will give us an idea on the range of fragment dispersion.

Model: We investigated the deformation using 3-Dimensional Smoothed Particle Hydrodynamics (SPH) method [2]. The hypothetical object is represented by 100 particles with a density kernel width of 45 m. Instead of sophisticated equation of state, we adopted isothermal incompressibility of water at room temperature and 1 atm, ie. 2.2 GPa. We do not take temperature into account. This unrealistic equation does not make our results meaningless because pressure has little effect on the deformation. The pressure works just to inhibit the gravitational collapse of the particles and only 10 Pa at most in this case. The equation of motion for each particle has terms for the pressure and gravitational forces due to the other particles and Jupiter. The equations were integrated numerically with time step of 10 sec.. We used the orbital parameters of SL-9 calculated by P. Chodas (personal communication) on the observational data of Mar. 17 - Jun. 6, 1993, that is, $a = 380\ R_J$ and $q = 0.53\ R_J$. Here, a, q and R_J are semimajor axis, peri-Jovian distance and radius of the planet, respectively. The positions of the body projected on its orbital plane are shown in Fig. 1 at some instances before the impact. The initial position and velocity of the center of mass of the particles are those at 2 hours before the impact calculated from the orbital parameters. Initial Jovian-centric distance to

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hours before the impact calculated from the orbital parameters. Initial Jovian-centric distance to the object is 4.3 R_J and the tidal force could be negligible there. The object is initially in hydrodynamic equilibrium without the tidal force. We made calculations for three rotational periods, 20 hours pro-grade (counter clockwise in Fig. 1), 20 hours retrograde, and non-rotation. The axis of the rotation is perpendicular to the orbital plane.

Results and Discussion: The positions of the 100 particles at the impact are projected on the orbital plane in Fig. 2 for non-rotating body. The object that is initially spherical in shape is elongated to spheroidal. However, it does not split. The ratio of the major to minor axes of the spheroid is 1.4. We found that the pro-grade rotation increases the ratio to 1.5 and retrograde one decreases it. This is because the tidal force acts in the same direction of the body for longer time for the pro-grade rotation than non-rotation. The angular velocity of the spin is yet smaller than that of the rotation of Jupiter-nucleus line. Shorter spin period would lead to a little more deformation.

The nuclei of SL-9 will not deform as shown in the simulation but split. The less their strength, the wider range their fragments would disperse. Then, the spheroidal surface of the hypothetical fluid nucleus would limit dispersion range. The results indicate that each nucleus of SL-9 will impact on Jovian atmosphere as a single pile of fragments though it splits due to the planet's tidal force.

REFERENCES: [1] Sekanina, Z. (1993) *Science*, *262*, 382. [2] Benz, W. (1989) in *Numerical Modeling of Stellar Pulsation: Problems and Prospects*.

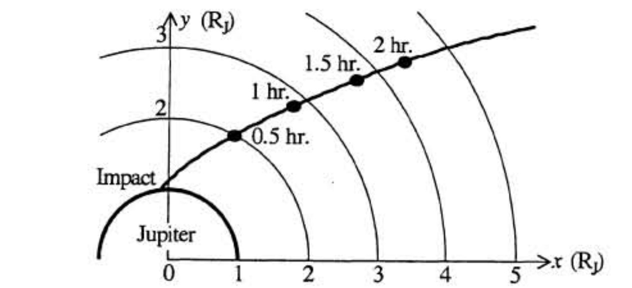

Fig. 1. The positions of one of SL-9 nuclei projected on its orbital plane at 0.5, 1, 1.5 and 2 hours before the impact on Jupiter. Jovian centric x and y axes are parallel and perpendicular to the semimajor axis of SL-9 that is now orbiting the planet.

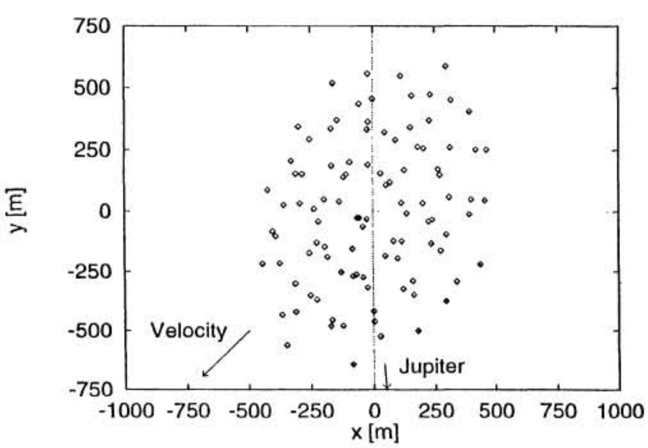

Fig. 2. A hypothetical SL-9 nucleus is represented by 100 particles. They initially formed a spherical body at 2 hours before its impact on Jupiter. The positions of them at the impact are projected on its orbital plane. The x and y axes are parallel and perpendicular to its semimajor axis, and the origin is the center of mass of the object. Also shown are the directions of velocity vector and Jovian center.