ESTIMATIONS OF PHYSICAL EFFECTS OF AN TERRESTRICAL 1 KM SIZE ASTEROID IMPACT. S. Lenzner, *Institute of Space Sensor Technology and Planetary Exploration, German Aerospace Center, Germany, (stephan.lenzner@dlr.de)*.

An impact of an asteroid with a size of 1 km or larger on earth occurs within a average time intervall of 300.000 years [1]. As the effects of an impact of this magnitude already might cause global devasations and impacts of larger magnitude, as the KT-impact event 65 Mio years ago, are believed to be responsible for some of the great mass extinctions in the history of earth [2], theoretical investigations of these events are helpful to understand geological and biological evolutionary processes on earth and to predict the consequences of such an event on human civilisation. The presented study intends to review some of the most significant physical effects. The analytic and numeric methods used allow to perform the investigations on high-performance personal computers. These investigations are:

- The atmospheric entry, the trajectory during the entry, the energy release into the atmosphere during the entry and the flowfield of the atmospheric gas affected by the speeding asteroid.
- The expansion of the vapour-plume in the atmosphere, in which the asteroid is converted after impacting on the ground.
- Global range effects as earthquake, the impact orcan and tsunami-propagation.
- Tsunami-generation at the impact site and the creation of the impact-crater.

Atmospheric Entry: For a 45 degree entry of a stony asteroid with 1km diameter in an altitude of 100 km the equations of motions for hypersonic velocities are solved to compute the trajectory and the energy release into the atmosphere during the entry. The entry velocity is set to 15 km/s. During the 9.3 seconds lasting entry only less than 1 % of the impactors energy is released into the atmosphere, creating a bow-shock of high energetic gas around the impactor. The velocity components in horizontal and vertical direction are only affected by some tens of meters per second. To compute the hypersonic flowfield quantities around the impactor, a flowsolver based on Mc. Cormac's technique [3] is applied on a structured grid containing 3600 knots. In the frame of reference of the moving impactor, which is assumed to retain it's size and shape during the entry, the flow enters the computational domain with ambient conditions in pressure and density and velocity equal to the speed of the impactor. As expected for hypersonic motions, the atmospheric gas is heated and compressed in the shape of a bow-shock around the impactor.

Expansion of the Vapour-Plume: After colliding with the surface of the planet, the impactor is converted into high compressed, high energetic vapour-plume which expands into the atmosphere. To simplify the investigation of this process, the initial vapour-plume is hemispherically with the radius equal to the radius of the former impactor, while the energy of the plume is set equal to 50% of the impactors energy. The planet's surface is assumed to be ideal reflecting. This assumptions lead to the initial flow quantities as energy-density and pressure of the flowfield in the atmosphere. The atmosphere is taken as isothermal with an exponentially decay in density and pressure. Similar assumptions for modelling this process are made by Newman et. al. [4], where the atmospheric blow-off of the KT-impact event is investigated. As the released energy of an 1 km size asteroid impact event into the atmosphere exeeds the treshold to balance with the ambient pressure, the vapour-plume expands above the characteristic scale height of the atmosphere through the stratosphere into space. To simulate this process numerically which covers a large variation in length- and time scales, the numerical scheme is equipped with a grid-stretching technique sensitive on arrival of the shock--wave at the upper outflow boundary.

Effects on Global Scales: Portions of the released energy of the impact propagate on global distances, significant are the global earthquake, impact-orcan and tsunamis if the impact takes place on sea where the depth of the water is sufficient large at the impact site. As numeric modelling of this global effects has to face difficulties due to huge variations in length- and time scales, analytical estimations are used to predict the amplitudes of these effects. Fundamental parameters in these estimations are the energy-partitions of these phenomenons, which are only rhoughly estimated at present and are subject to further research.

Tsunami- and Impact-Crater Creation: Specializing the flowsolver described above on quasi incompressible fluids, the creation and propagation of tsunami-waves can be studied at the impact site. For this purpose, in a quasi incompressible fluid with a given depth a transient cavity is taken as initial condition and the process of filling under the influence of gravity is investigated with respect to time. The size of this transient cavity is taken from Crawford [5]. It is visible, that the fluid forms a huge fountain after filling the cavity, which collapses and generates a series of tsunami-waves. The two--dimensional, radial symmetric model is also equipped with a profile of the ocean floor which rises to a shallow-water region at the radial boundary of the domain. This allows to observe the increase of the wave-heigth as they reach the shallow-water region.

The interaction of the impactor with the planet's surface is investigated using a two-fluid hydrodynamic code. The upper atmosphere and the impactor are described by species 1, the material of the surfaces by species 2. For species 1 a ideal gas equation including cold pressure effects (when the impactor is compressed above it's normal density) is used, while for the species 2 the tillotson equation of state is applied [6]. Also in this case the grid-stretching method is applied to cover the wide range of length-scales from the initial size of the impactor to the final size of the crater. The shape of the impactor and the surface material is marked with tracer-particles [7] which allow to observe the deformation of the impactor and the excavation flow created by the impact. The method is capable to compute more than 150 characteristic times. As this method also is based on the Mc. Cormac's technique where artifical viscosity is needed in the presence of shocks, the interface of impactor and planet's surface becomes smeared out in the density distribution during the computation. Either an upwind technique applied in the flowsolver or a density reconstruction based on volume cells defined by the tracer-particles positions are planned to sustain a sharp interface.

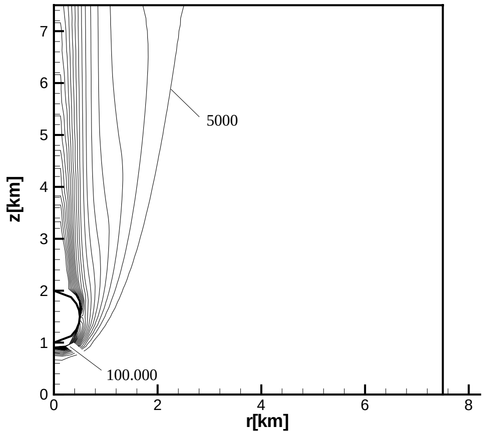

Figure 1: Temperature profile around impactor , $T_{min} = 5000K, \Delta T = 5000K$

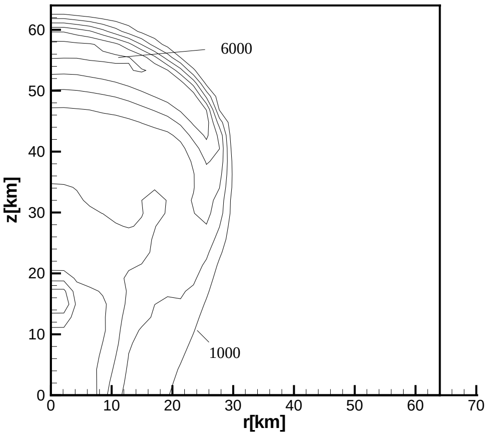

Figure 2: Temperature in vapour-plume after $9.22s$, $T_{min} = 1000K, \Delta T = 1000K$

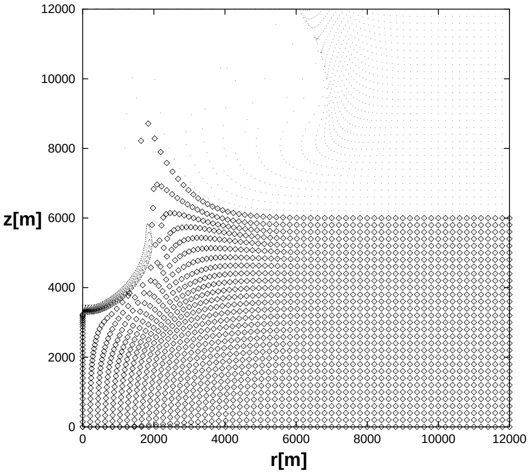

Figure 3: Position of the tracer-particles at t = 1 s

Figure 1 illustrates the temperature distribution around the moving impactor in the lower part of the atmosphere. In figure 2 the temperature distribution in the expanding vapour-plume 9.22 sec after the begin of the expansion is shown. The deformation of the projectile as the created transient cavity in the surface, consisting of water-ice, is illustrated in figure 3. Aslo visible in figure 3 is the outgoing shock-wave in the atmosphere.

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