TRIGGERING PRESOLAR CLOUD COLLAPSE AND INJECTION OF SHORT-LIVED RADIOISOTOPES BY A SUPERNOVA SHOCK WAVE

A. P. Boss[1], S. I. Ipatov[1], and E. A. Myhill[1,2]. [1]DTM, Carnegie Institution of Washington, 5241 Broad Branch Road NW, Washington, DC 20015-1305. E-mail: boss@dtm.ciw.edu [2]Marymount University, Arlington, Virginia

The short-lived radioisotope (SLRI) ^{60}Fe must have been synthesized in a supernova [1,2] and then either injected into the presolar cloud [3,4] or onto the surface of the solar nebula [5]. A similar nucleosynthetic event is likely to be the source of the bulk of the solar nebula's ^{26}Al [6,7] and of other SLRIs. Here we reconsider the problem of triggering the collapse of the presolar cloud and of simultaneously injecting SLRI with a supernova shock wave. Previous work on this problem [3,4,8,9,10] used either fixed grid or smoothed particle hydrodynamics (SPH) codes with a limited ability to resolve fine scale structure in the Rayleigh-Taylor fingers that form at the shock/cloud interface and are responsible for SLRI injection into the collapsing presolar cloud [9]. Here we study the same problem with an adaptive mesh refinement hydrodynamics code, FLASH, which provides a superior ability to resolve small-scale structures. We have verified the accuracy of FLASH on three test cases relevant to the problem of triggering cloud collapse, namely the Sod shock tube problem, the collapse of a pressureless sphere, and the long-term stability of the target cloud. We have reproduced the main results of [8,9] in 2D cylindrical coordinates with isothermal thermodynamics and a range of shock speeds (2 to 40 km/s), finding that shocks with speeds in the range of 5 to 30 km/s are able to both trigger collapse and inject shock wave material. We are extending these isothermal runs to 3D Cartesian coordinates to learn what happens in a fully 3D cloud. We then intend to study nonisothermal shocks. [10] found that when nonisothermal shocks were employed in SPH calculations, it was not possible for a shock wave to simultaneously trigger collapse and inject SLRIs, a potentially fatal flaw for the triggering and injection scenario. However, [11] found that improvements in the dust grain cooling model led to rapid post-shock cooling, closer to the isothermal assumptions used in [3,4,8,9]. Our ultimate goal is to use FLASH to determine if the triggering and injection scenario [12] is consistent with post-shock cooling processes. The software used in this work was in part developed by the DOE-supported ASCI/Alliances Center for Astrophysical Thermonuclear Flashes at the University of Chicago.

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