SUPERNOVA SHOCK TRIGGERING AND INJECTION INTO THE PRESOLAR CLOUD: EFFECTS OF ROTATIONAL AXIS ORIENTATION

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Introduction: Observations of Type II supernova (SNe) remnants (SNR) and their interactions with cloud complexes reveal the presence of dense clumps of molecular gas that have been struck and compressed to small sizes by the SNR [1,2,3]. Detailed 2D [4] and 3D [5-7] hydrodynamical models of shock waves with parameters similar to SNRs have demonstrated the viability of triggered collapse of dense cloud cores with simultaneous injection of shock front material into the resulting collapsing protostar and protoplanetary disk. A SNR shock appears to be the leading contender for achieving simultaneous triggering and injection of short-lived radioisotopes (SLRIs) into the presolar cloud and the resulting solar nebula [8]. Data on ferromagnesian chondrules from two ordinary chondrites (OC) implied initial ^{60}Fe /^{56}Fe ratios of 5-10 x 10^{-7} [9], whereas bulk sample data from a wide range of meteorites suggested an initial ratio of 1.15 x 10^{-8} [10]. A combined study of ^{60}Fe and ^{26}Al in chondrules from unequilibrated OC (UOC) implied an initial $^{60}Fe/^{56}Fe$ ratio of 7 x 10^{-7} [11] and supported a SNe as the source of the SLRIs. Analyses of other chondrules from UOC yielded Fe ratios in the range of 2-8 x 10^{-7} [12]. There is as yet no explanation for the discrepancy between bulk samples and chondrule fragments [12], but a SNe remains as a plausible source for the SLRIs. Indeed, evidence for possible live ^{135}Cs in CAIs suggests its origin in a Type II SNe (or its WR progenitor) close to the presolar cloud [13]. Furthermore, evidence for live ^{10}Be in FUN-CAIs appears consistent with ^{10}Be formation in the presolar molecular cloud by galactic cosmic rays emitted by a SNR that thereafter triggered the collapse of the presolar cloud core [14]. Statistical analysis of the SLRI enrichments expected for disks and cloud cores in clusters containing massive stars show that cloud cores receive a larger dose on average than disks [15], favoring injection into the presolar cloud [8] rather than the solar nebula [16].

Models: Results are presented for a set of 3D models identical to previous rotating cloud models [4,6], but with the rotation axis perpendicular to the shock front direction, rather than parallel.

Results: Collapsing central protostars and disks form in all of the models, though with disk spin axes deflected considerably. Injection efficiencies are ~0.03 in these models, as before [5,6].

Conclusions: Altering the rotation axis orientation has only a minor effect on the outcome. The SNe triggering and injection scenario remains as a leading explanation for the Solar System's SLRIs. Future work will investigate nonisothermal collapse.

References: [1] Sashida, T., et al. 2013. *ApJ*, 774:10. [2] Reach, W. T., et al. 2005. *ApJ*, 618:297. [3] Blair, W. P., et al. 1999. *AJ*, 118:942. [4] Boss, A. P. and Keiser, S. A. 2013. *ApJ*, 770:51. [5] Boss, A. P. and Keiser, S. A. 2012, *ApJL*. 756:L9. [6] Boss, A. P. and Keiser, S. A. 2014. *ApJ,* 788:20. [7] Li, S., et al. 2014. *MNRAS*, 444:2884. [8] Boss, A. P. 1995. *ApJ*, 439:224. [9] Tachibana, S., et al. 2006. *ApJ*, 639:L87. [10] Tang, H. and Dauphas, N. 2012. *EPSL*, 359-360:248. [11] Mishra, R. K. and Goswami, J. N. 2014. *GCA*, 132:440. [12] Mishra, R. K. and Chaussidon, M. 2014. *EPSL*, 398:90. [13] Bermingham, K. R., et al. 2014. *GCA*, 133:463. [14] Tatischeff, V., et al. (2014), *ApJ*. 796:124. [15] Adams, F. C., et al. 2014. *ApJ*, 789:86. [16] Ouellette, N. et al. 2007. *ApJ*, 662:1268.