Numerical study of the adiabatic index effect for the Vishniac instability in supernova remnants

C. Cavet[1], C. Michaut[1], F. Roy[1], H. C. Nguyen[1,2], S. Bouquet[3,1], C. Sauty[1]

[1]*LUTh, Observatoire de Paris, CNRS, Université Paris-Diderot ; place Jules Janssen, 92190 Meudon, France, cecile.cavet@obspm.fr*

[2]*Laboratoire de Mathématiques, Université Paris-Sud, Orsay, France*

[3]*CEA-DAM-DIF, F-91297 Arpajon Cedex, France*

The Vishniac instability [1, 2] discovered analytically in the context of radiative shocks and invoked to explain the fragmentation of the shock front of supernova remnants is not well known nowadays. With numerical simulations, we want to understand the effect of the instable theoretical parameters on the triggering and on the growth of the instability. Previously [3] we realized with the HYDRO-MUSCL2D code, numerical simulations of a cylindrical thin shell perturbed with high-density spots. This technique does not allow to control the perturbation wavenumber. In a new approach we chose to introduce on a plane-parallel thin shell a sinusoidal perturbation with a specific amplitude and wavenumber. By means of the Titane supercalculator (CCRT/GENCI/CEA, France) we made a parametric study of the Vishniac instability and we present here the adiabatic index effect. To realize the numerical simulations we set the amplitude to initiate the linear regime of the instability and we set the Mach number ($\mathscr{M} \sim 4$ - 5) to have a suitable dynamic. For the instable wavenumber range and for three adiabatic indexes (γ = 1.1, 1.4 and 5/3) we compare the oscillations of the perturbation mass δM calculated in a specific region (valley or hill). We find different behaviors of δM for $\gamma = 1.1$ and for $\gamma > 1.1$: the instability only grows consequently and degenerates for $\gamma = 1.1$ in agreement with the theoretical analysis and validates constraints for the laboratory experiments. Thus the experimental project in collaboration with Edens et al. on the Z-Beamlet laser (La Sandia) could manage to prove the existence of the Vishniac instability in laboratory.

References

[1] Vishniac, E. T., Astrophys. J., The dynamic and gravitational instabilities of spherical shocks, 274, 152, 1983

[2] Ryu, D., Vishniac, E. T., Astrophys. J., The growth of linear perturbations of adiabatic shock waves, 313, 820, 1987

[3] Cavet, C., Nguyen, H. C., Michaut, C., Falize, E., Bouquet, S., di Menza, L., Theoretical and numerical studies of the Vishniac instability in supernova remnants, 322, 91, 2009

8th International Conference on High Energy Density Laboratory Astrophysics
March 15-18, 2010
California Institute of Technology
Pasadena, California, USA
http://hedla2010.caltech.edu/