3DMAP-VR

A Virtual Reality Tool for Analysis of 3D MHD Astrophysical Simulations

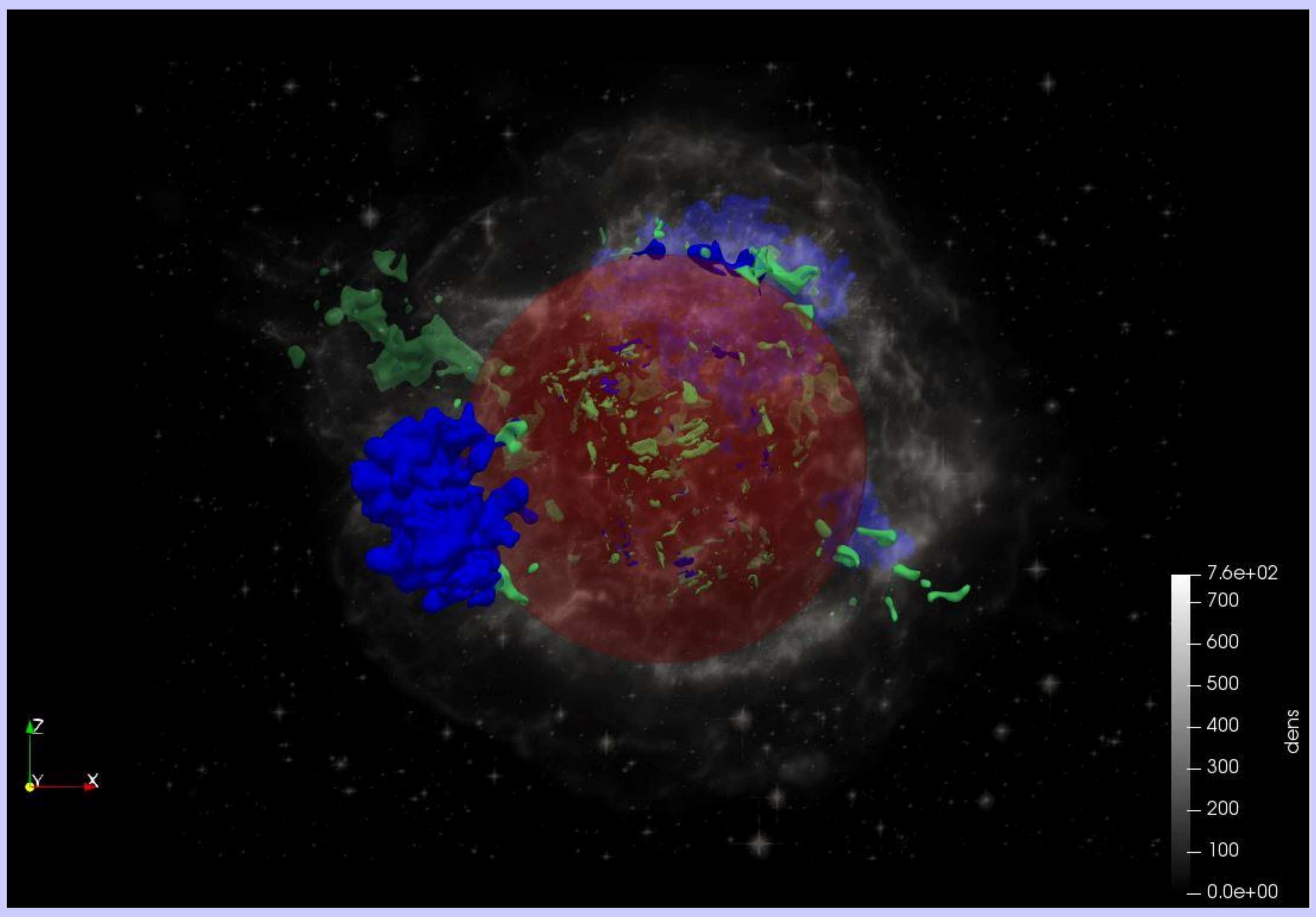
F.Bocchino[1], S. Orlando[1], I. Pillitteri[1], M.Miceli[2], G. Peres[2]

[1]INAF-Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy
[2]Università di Palermo, Dipartimento di Scienze Fisiche ed Astronomiche, Via Archirafi 36, 90100 Palermo

Abstract

Virtual Reality (VR) hardware and software are now routinely used in several fields for public outreach and education with excellent feedback. For this purpose, YouTube and online multimedia digital stores have several VR titles of great impact in the Astrophysics and Space categories of their catalogues. However, scientific use of VR environments are still at their beginning. Fully 3D Magneto-hydrodynamical simulations of astrophysical phenomena represent a challenge in standard data visualization for scientific purposes, for the amount of processed data and the wealth of scientific information they contain. In this poster, we present a 3DMAP-VR, a project started at INAF-Osservatorio Astronomico di Palermo for data visualization of 3D MHD models of Supernova Remnants and Young Stellar Objects, using VR equipments. This tool, an extension of the Paraview software, allows to quickly have a VR representation of the model to be used to analyze the numerical results in an immersive fashion, complementing the traditional on-screen visualizations.

We have prepared 3 VR scenes, using published MHD models of SN87a, Cas A and SN1006 developed at INAF-OAPa. During coffee-breaks and poster times, we offer a VR experience of these scenes to attendees. You are welcome to come at any time, but we will give priority to reservations made using the online form available at http://3dmap-vr.dynu.net:8080/ or the QR code below.



Scene #1: SN87a

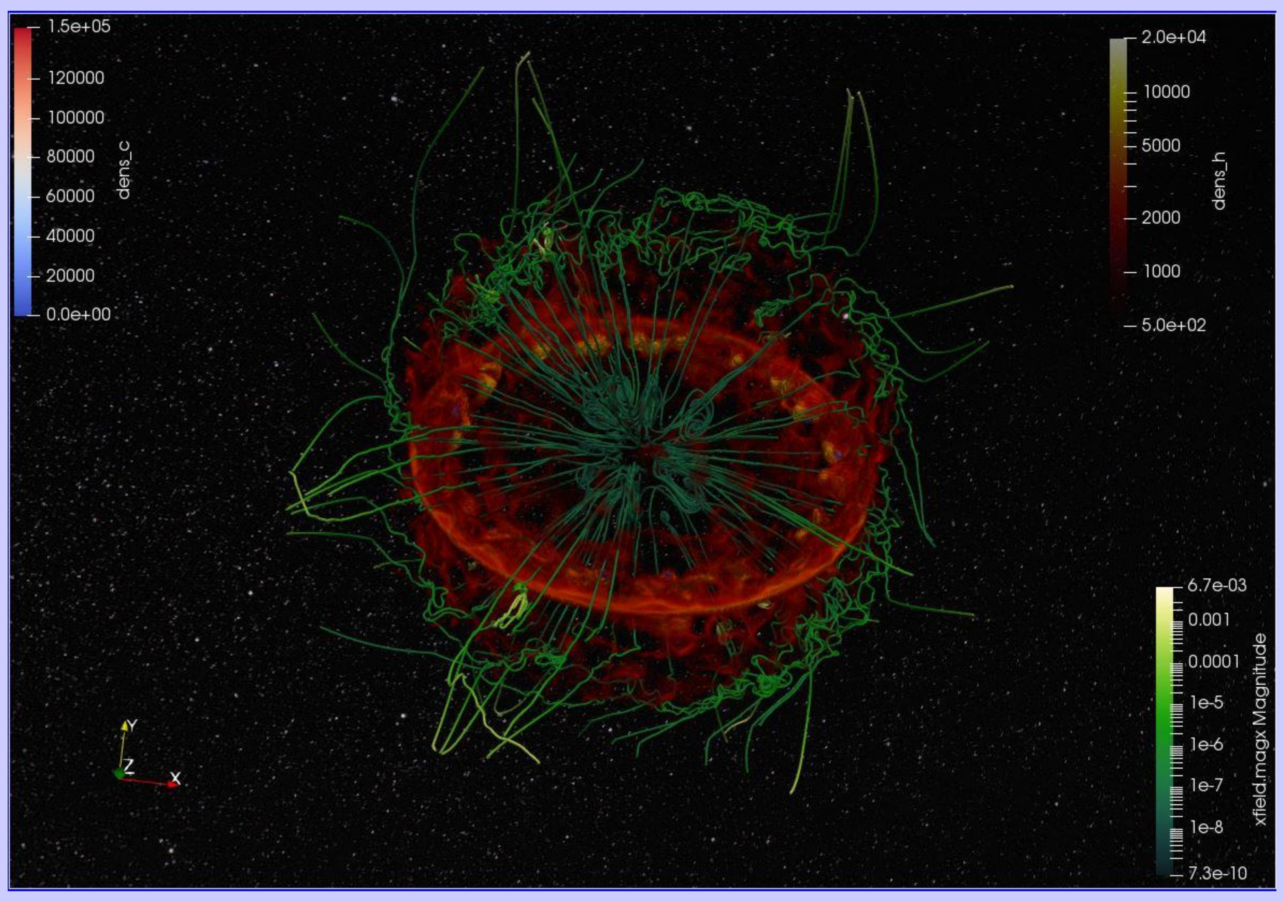
This scene represent a MHD simulation of SN87a at the age of 32 yr (today). The model, developed by Orlando et al. (2019, A&A, 622, A73), shows the role of B in shaping the turbulent interaction regions in the dense equatorial ring.

What you will see:

1. Shocked material with $T > 10^6$ K is represented by multi-layers in RED scale (density values in cm-3 in the color bar), while unshocked material in BLUE (single isodensity surface)
2. The magnetic field lines are also drawn in the proximity of the shocked ring

What you can do:

- Get closer and a clipping plane automatically will appear, so inner regions become visible
- Look how the shocked and unshocked material are still very separated. Unshocked material is radio-quiet.
- Explore anisotropies in the distribution of stellar debris resulting from the large scale asymmetry in the SN explosion
- Look how B follows anisotropies and quench ring fragmentation.



Scene #2: Cassiopea A

This scene represent a HD simulation of the Supernova Remnant Cas A at the age of 340 yr (today). The model we used is described in Orlando et al. (2016, ApJ, 822, 220)

What you will see:

1. The RED transparent sphere is the nominal position of reverse shock
2. In BLUE, isodensity surface of Fe-rich shocked ejecta.
3. In GREEN, isodensity surface of Si- and/or S-rich shocked ejecta
4. A combined Chandra X-ray and HST image is shown in a plane crossing the SNR center (from Patnaude et al. 2014, ApJ, 789, 138)

What you can do:

- Explore the interiors of the remnant and the inner part of the ejecta blobs. A clipping plane will automatically appear. You will notice in some cases Si-rich blobs inside Fe-rich blobs: those are the high-mixing regions.
- Explore the asymmetries of Fe-rich ejecta, due to post-explosion ejecta anisotropies developed soon after the SN event
- Explore the structure of the Si jet and counterjet.

Scene #3: SN1006

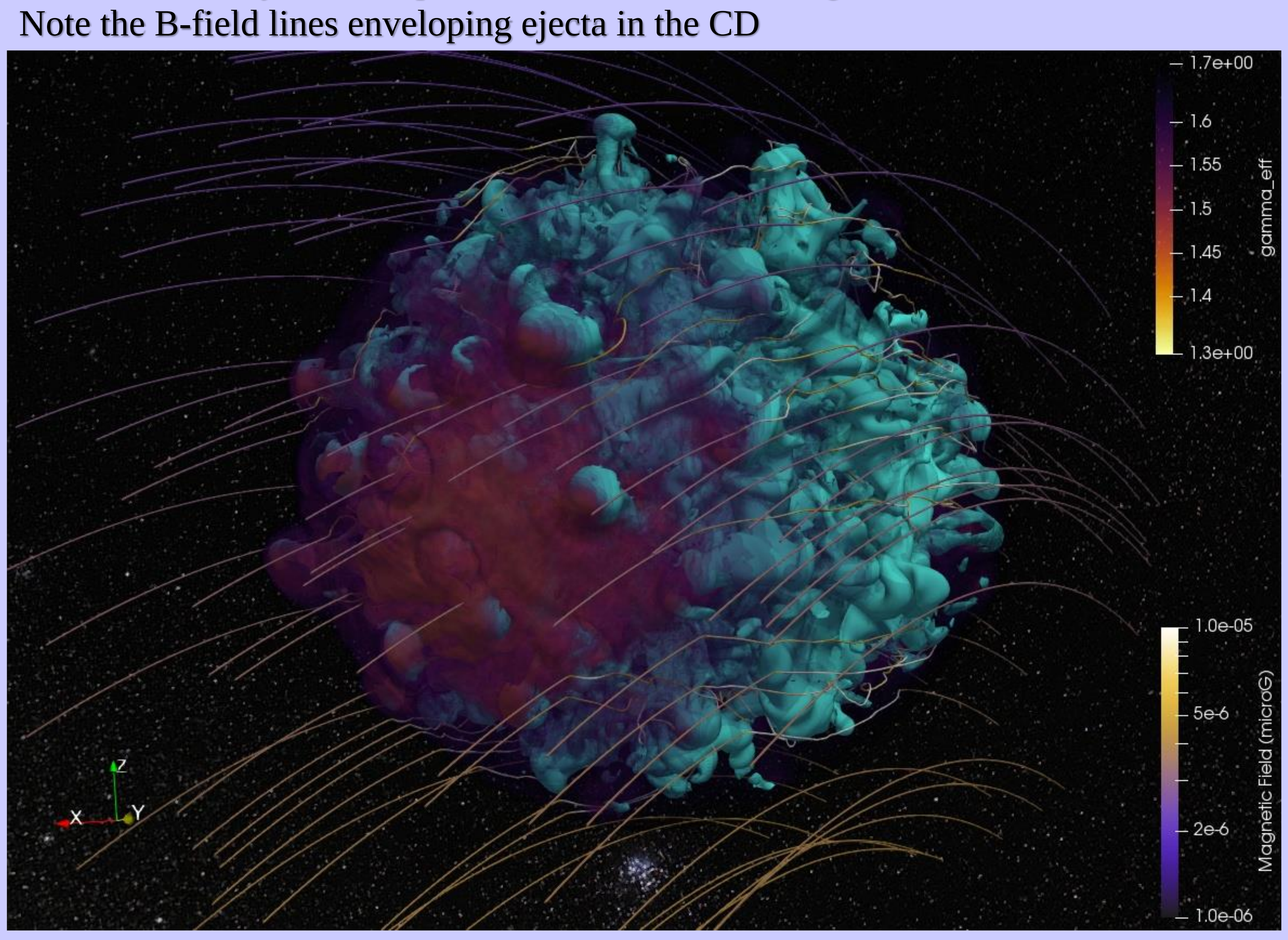
This scene represent a MHD simulation of the Supernova Remnant SN1006 at the age of 1015 yr (today). The model we used is decribed in Orlando et al. (2012, ApJ, 749, 156)

What you will see:

1. The large scale magnetic field lines are drawn in the scene. Small scale magnetic field is represented with arrows, with size proportional to intensity (within the forward shock only)
2. In CYAN isodensity surface of shocked ejecta. In the simulation, the ejecta are traced using a passive tracer and here cell with ejecta tracer > 90% in volume are represented.
3. In YELLOW/BLUE scale, we map the effective adiabatic index (γ_{eff}) value modified by diffusive shock acceleration, using the multi-layers tecnique. Note that the γ_{eff} is a sort of proxy of the main shock.

What you can do:

- Since γ_{eff} map the position of the main shock, you will notice bow-shocks around shell protrusions. Note that short separation between ejecta and forward shock even in region where $\gamma_{eff} = 4/3$!!! This separation is not indicative of shock acceleration but of intrinsic ejecta clumpiness evolved until late stages.
- Note the B-field lines enveloping ejecta in the CD



Technicalities and Conclusions

1. The MHD simulations were perfomed using the PLUTO code (Mignone et al. 2007) and the FLASH code (Fryxell et al. 2000)
2. The scenes were realized using Paraview and its plugin OpenVR. This software is developed by Kitware Inc and distributed under a permissive BSD license (paraview.org).
3. We use the a mixed technique consisting of multi-layers isodensity surfaces with different opacities. We use the commercial VR viewer Oculus Rift
4. **Scan the QR code to make a reservation for VR scenes on display with the Oculus Rift during coffee breaks or go to http://3dmap-vr.dynu.net:8080/ .**

Scan me