

Numerical simulations, tools for data visualizations and High Performance Computing at INAF-OAPa

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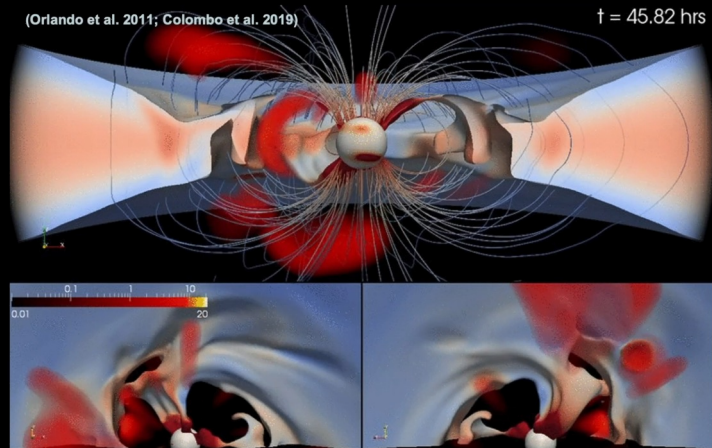
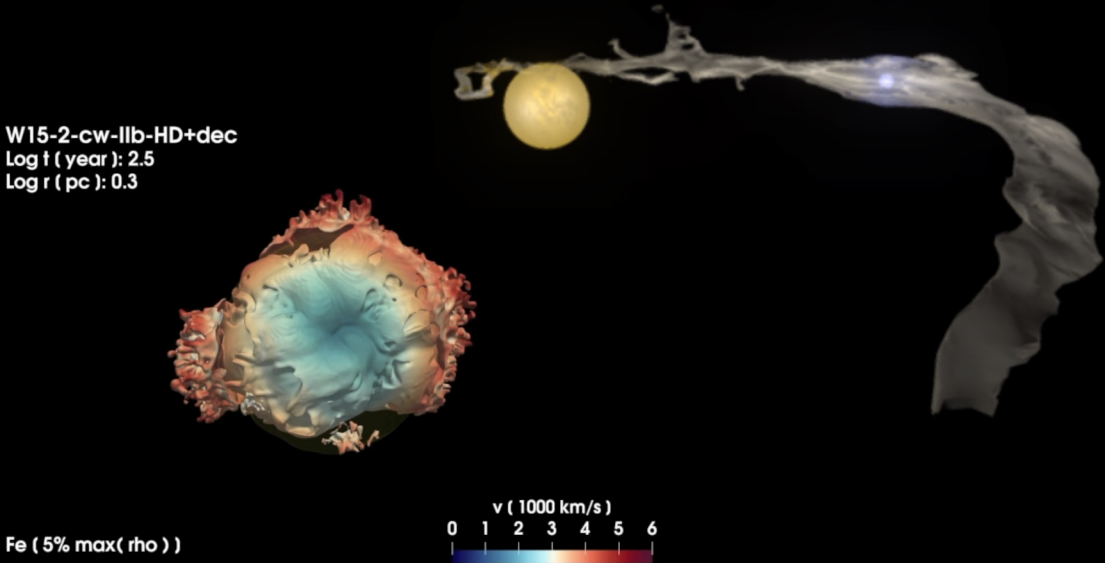
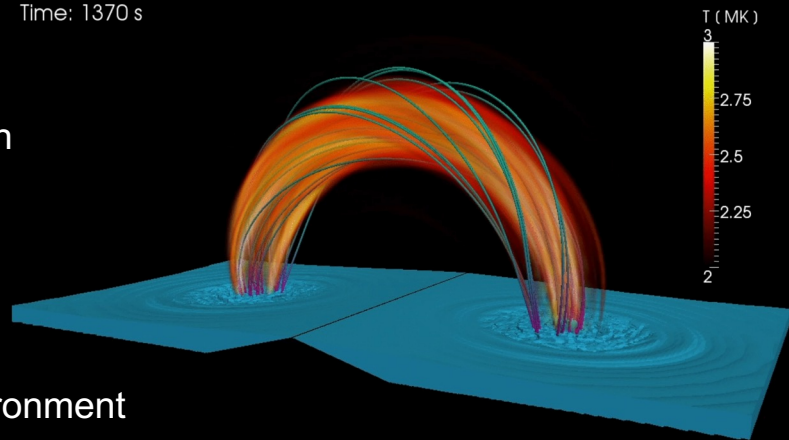


PARTNERSHIP FOR ADVANCED
COMPUTING IN EUROPE

Main Research Lines

- Dynamics of magnetic structures in the solar corona
- Physics of accretion phenomena in young stellar objects
- Evolution of protostellar jets and origin of their X-ray emission
- Star – planet interaction
 - Stellar activity
 - Properties of planetary atmospheres
- Evolution of nova outbursts
- Interaction of supernova remnants with the surrounding environment
- The progenitor star – supernova – supernova remnant connection
- Effects of cosmic ray particle acceleration on the evolution of supernova remnants

Time: 1370 s



Numerical codes

HD/MHD codes

- **Use of existing codes** (setup, customization, new numerical modules)
 - PLUTO (3D HD/MHD, **MPI**) UNITo + OATo + CINECA (Italy)
 - FLASH (3D HD/MHD, **MPI**) University of Chicago (USA)
 - MESA (1D stellar evolution, **OpenMP**) MESA Team (USA)
- **Development of new codes**
 - PALERMO-HARVARD, SIPHON, EOLO (1D HD, solar corona and wind)
 - OPHELIA (NEI)

Tools for data modeling, analysis and visualization

- **Use of existing tools**
 - IDL, python (general, data analysis)
 - ParaView, Visit (general, data visualization)
 - Sketchfab (general, data visualization, VR and public outreach)
 - TAUREX (Tau retrieval for exoplanets; **MPI**) UCL (UK)
- **Development of new tools**
 - SpAct (python bayesian framework to model stellar activity, **MPI**)
 - CPcross (calculate absorbing coefficients of planetary atmospheres; **multi-threading**)
 - RSG2SNII (parallel pipeline for massive photometry and lightcurve analysis with the aid of machine learning techniques, **farming**)
 - IDL library to synthesize thermal emission (LR/HR spectra, images, lightcurves) (**python+MPI**)
 - REMLIGHT (synthesis of synchrotron emission in different bands)

Facilities

EXTERNAL

- CINECA (PRACE)
- BSC (Spain) (PRACE)
- CINES (France)
- Pleiades@NASA (USA)



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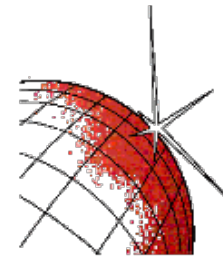
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PARTNERSHIP FOR ADVANCED COMPUTING IN EUROPE

IN-HOUSE FACILITY

- Sistema di Calcolo per l'Astrofisica Numerica (SCAN)
 - **MEUSA:** 72 nodes, each with 68-cores Intel Xeon Phi7250 (Knight Landing) at 1.4 GHz; Intel Omni-Path architecture.
 - **CORVUS and SCAN2:** each with a single node with 64-cores AMD (Opteron Barcelona 2354, 2.2 GHz); Infiniband.
 - **SPHINX:** six nodes each with 8-cores and two nodes each with 12 cores, for a total of 72 CPUs and 144 GByte of memory RAM; Intel (Xeon Harpertown E5420, 2.5 GHz) and AMD (Opteron Barcelona 2354, 2.2 GHz); InfiniBand.



SCAN

Sistema di Calcolo per l'Astrofisica Numerica
Computational System for Numerical Astrophysics

Extension to 72+72 nodes by the end of 2022

Post-processing of numerical simulations

MEUSA (KNL)

ACTIVE USERS: 11

ACTIVE PROJECTS: 13

MHD avalanche in a multi-threaded coronal loop	G. Cozzo	MPI; 640 cores; 500 GB)
Data-driven reconstructions of the interplanetary Parker spiral with the reverse in-situ and MHD approach	R. Biondo	MPI; 512 cores; 120 GB
MHD simulations of star-planet interaction	S. Colombo	MPI; 960 cores; 1 TB
CME interaction with the atmospheres of hot Jupiters	S. Colombo	MPI; 960 cores; 20 TB
A bayesian framework to extract radial velocities from high resolution spectroscopic data	C. Di Maio	MPI; 640 cores; 50 GB
A bayesian framework to model high cadence lightcurves of active stars	G. Cracchiolo	MPI; 640 cores; 50 GB
A bayesian framework to model multiband photometry of active stars	A. Biagini	MPI; 256 cores; 50 GB
Analysis of planet mass uncertainties on atmospheric retrieval accuracy	C. Di Maio	MPI; 256 cores; 50 GB
Cross sections in atmospheres of Earth-like planets	A. Petralia	Farm.; 256 cores; 20 GB
Modeling the progenitor-SN-SNR connection	S. Orlando	MPI; 2304 cores; 4 TB
Origin of the mixed-morphology and overionized plasma in SNRs	S. Ustamujic	MPI; 1280 cores; 1 TB
A self-consistent model of the CSM and the SN-SNR of Cassiopeia A	D. Zarcone	MPI+OpenMP; 2304 cors; 4 TB
Unveiling the pre-SN magnetic field of SN 1987A through radio polarization maps and MHD simulations	O. Petruk	MPI; 2304 cores; 2 TB

solar physics **stellar activity and exoplanets** **supernovae and their remnants**

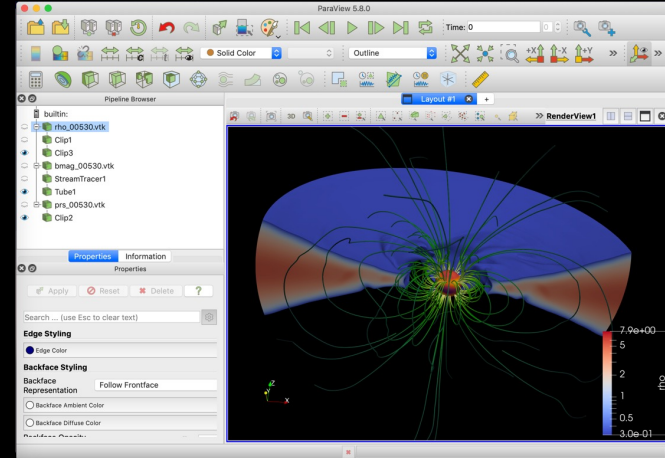
The 3DMAP-VR project



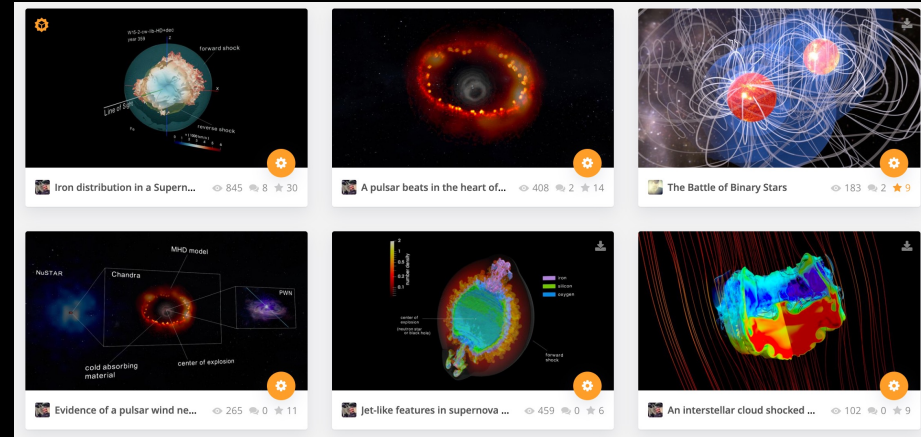
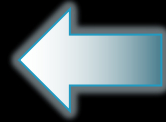
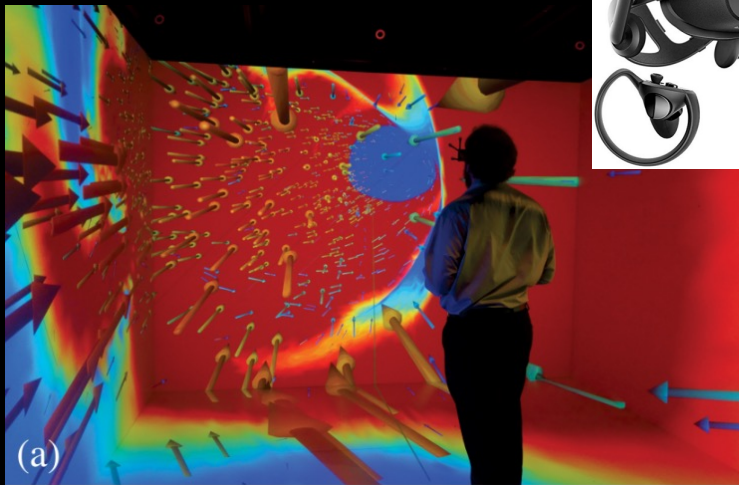
supercomputers



Data analysis and visualization



Public galleries of interactive graphics, VR, AR



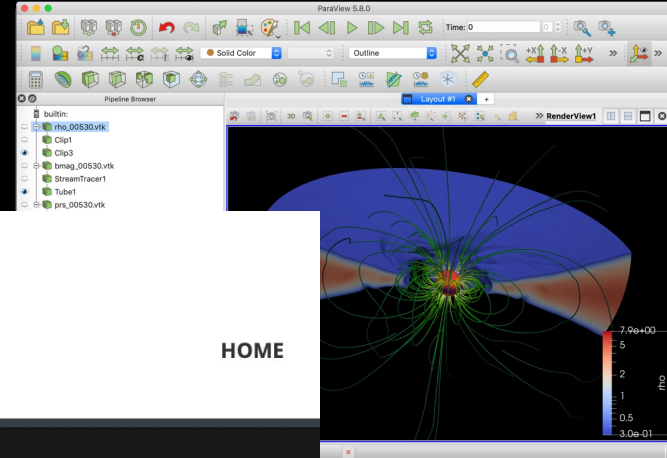
The 3DMAP-VR project



supercomputers



Data analysis and visualization

The logo for PHAROS, featuring a stylized sine wave and a black circle with a white dot inside.

PHAROS
THE MULTI-MESSENGER
PHYSICS AND ASTROPHYSICS
OF NEUTRON STARS

HOME

HOME > STAR BLAST: A VR TOUR OF THE OUTCOME OF STELLAR EXPLOSIONS

Star Blast: a VR tour of the outcome of stellar explosions

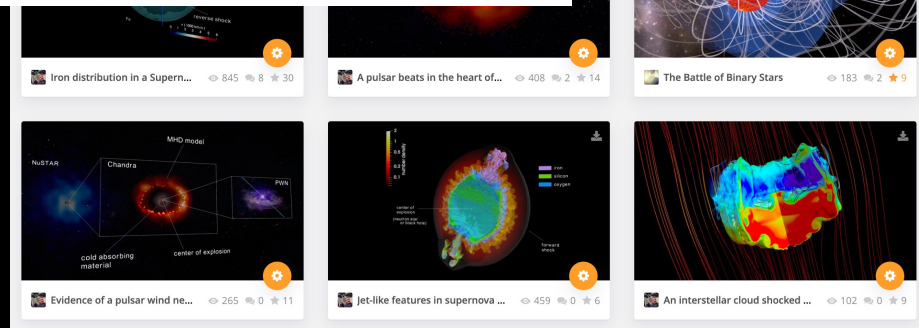
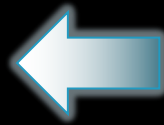


Star Blast: a VR tour of the outcome of stellar explosions

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(a)



Involved people

Personnel performing numerical simulations or post-processing (17 researchers)

Solar corona	YSOs	Exoplanets	Nova outbursts	SN-SNR	Cosmic rays in SNRs
F. Reale G. Cozzo R. Biondo A. Petralia (S. Orlando)	S. Orlando S. Colombo S. Ustamujic (R. Bonito)	S. Colombo I. Pillitteri A. Petralia C. Cecchi-Pestellini C. Di Maio A. Biagini	S. Orlando	S. Orlando S. Ustamujic O. Petruk D. Zarcone M. Miceli F. Bocchino E. Greco	S. Orlando O. Petruk M. Miceli F. Bocchino

Personnel involved in farming or post-processing
 Personnel not active in the specific research line in the last 5 years

Public outreach
L. Daricello L. Leonardi R. Bonito S. Orlando F. Bocchino

Scientific production in the last ten years

- Several refereed papers (including 53 papers on HD/MHD simulations);
- Several invited and contributed talk/poster presentations at international meetings;
- Accepted proposals for numerical resources (including 3 PRACE projects and 2 PRACE-ICEI projects).
- Web page, public outreach products (3D interactive graphics, movies, figures)
- Models developed for NASA and the California Academy of Science