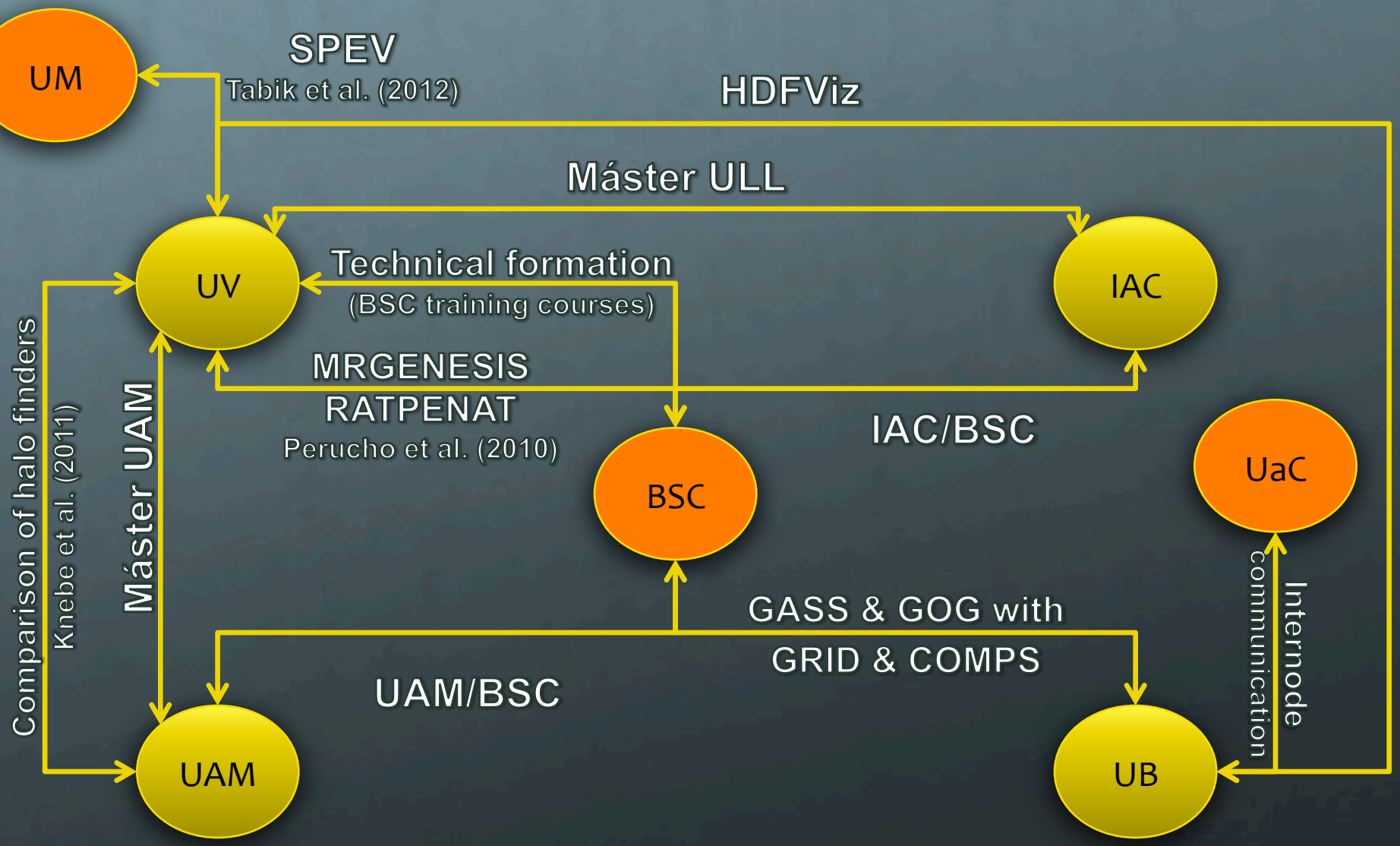
WP6: Grand Challenge in Astrophysics

Final Report

WP6: Grand Challenge in Astrophysics

SyeC Supercomputación y eCiencia	Relativistic outflows and their non-thermal signature UV	Cosmological simulations of galaxies and clusters UAM	3D models of magnetized flows, waves and giant eruptions in the Sun and stars IAC	Data simulation and processing for the Gaia space mission UB
Scientific Milestones	Transport scheme for RMHD: *Mimica, et al. (2009)* The missing link between NS-mergers and GRB bursters: *Rezzolla, et al. (2011)* ***Starting Independent Researcher Grant (2010) awarded to Prof. Aloy***	Large Scale simulations of structure formation in the Universe at different scales: • *High-z CURIE and MareNostrum Universe* • *GALFOBS* • *Constrained Local Universe Simulation (CLUES)* • *MUSIC project (galaxy clusters)* • *JUBILEE (6Gpc Box)* • *BigMD (2.5 Gpc Box)*	• First 3D model of observed X-Ray jets in solar coronal holes. • Cosmic element abundances: magnetic effects proved important • first 3D model of subsurface helioseismic waves in sunspots	• Large mission simulations using realistic Universe and Instrument models • Detailed design of the raw data re-processing and calibration system (IDU). • Assessment of IDU concept (end-to-end tests, improve-ments in image parameters)
Computational Milestones	• OpenMP/MPI versions of exis-ting codes **(col. with BSC):** **MRGENESIS** **RATPENAT** • Efficient use of up to **7000 CPUs** on RES • Improvement of **SPEV. (col. with U. Malaga)**	• New Initial conditions generation code: GINNUGAGAP • Parallel MPI version of the P-DEVA simulation code • New MPI halo finder code AHF • Databases for simulation results: • http://jubilee-project.org • http://music.ft.uam.es • http://curiehz.ft.uam.es	• Creation of a new 3D MPI-parallel MHD code • CPH Stagger Code applied to the cosmic abundance problem including magnetic fields	• GASS and GOG simulators with GRID and COMPS superscalar (col. BSC), up to **3700 CPUs.** • EIDU processing of 1.5 yr of downscales mission data in 5 days (Gaia/DPAC end-to-end tests). • **300Mbps** transfers with ESAC (Madrid).
Consolider SyeC key for	1. Contracts of Dr. P. Mimica, C. Aloy and J.E. Adsuara. 2. Computational time from the RES and PRACE. 3. Producing a highly optimized version of MRGENESIS/SPEV.	1. Contracts of Oñorbe, Gonzalez, Knollmann, Campos, Zamora 2. Obtaining computational time from the RES and PRACE. 3. Producing a highly parallel and optimized version of simulation and initial conditions generation codes	1. Contracts of Drs. A. F. Rappazzo, D. Fabbian and L Yelles-Chaouche 2. Large computing grants from PRACE, DEISA and RES 3. Testing and using on PowerPC computers the CPH Stagger Radiation-MHD Code	1. Contract of Y. Isasi and R. Borrachero (simus) 2. Computational time (BSC) 3. Efficient software deploy-ment (col. BSC) 4. Efficient inter-node communication (col. UaC)

Networking and synergies



Publications & Scientific Impact (2008-2012)

Work done within SyeC	UV		UAM		IAC		UB		WP6		Goal SyeC (2007-2012)
Full Time Equivalent / yr	5.5		6		3		3				
	A	T	A	T	A	T	A	T			
Papers (peer review)	42	84	45	90	22	79	17	39	128	253	50
Proceedings	29	77	22	88	27	71	18	73	96	309	
Invited talks	20		16		25		10		45		
Mass media	3		3		5		8		19		
Technical notes	-		-		-		315		315		

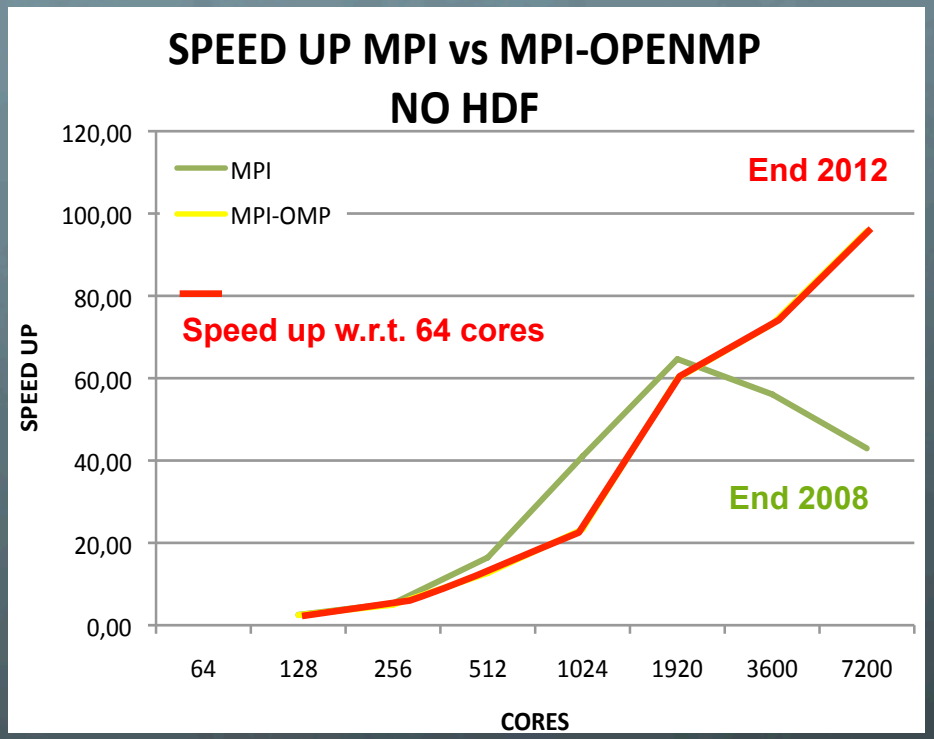
A: Publications directly related with the SyeC project.
T: Total number of publications of the group (including SyeC project).

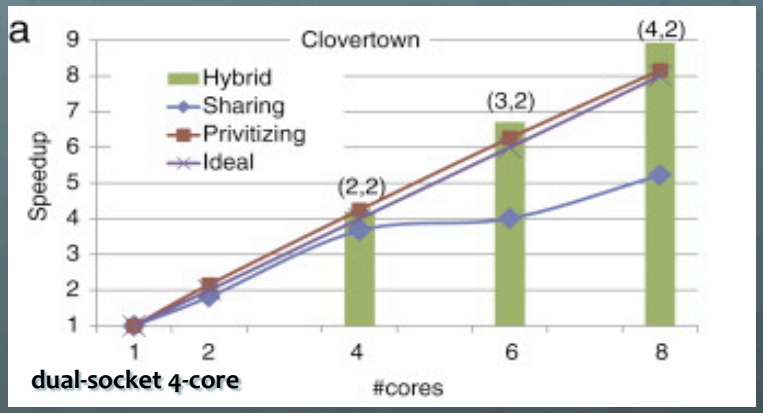
Relativistic Astrophysics and Cosmology

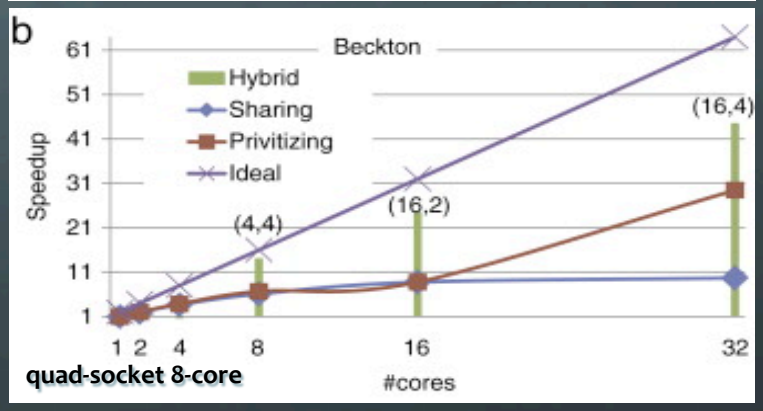
- **Staff:**
  - **P.I.: José Mª. Ibáñez** (Full Prof., UV)
  - **José A. Font** (Asoc. Prof., UV)
  - **José Mª. Martí** (Asoc. Prof., UV)
  - **Vicent Quilis** (Asoc. Prof., UV)
  - **Miguel A. Aloy** (Asoc. Prof., UV)
- **Faculty:**
  - **Petar Mimica** (UV)
  - **Pablo Cerdá** (UV)
  - **Manel Perucho** (UV)
  - **Isabel Cordero, Pedro Montero** (MPA)
- **Computer Scientists:**
  - **Carmen Aloy** (PTA-MICINN)
  - **José E. Adsuara** (SyeC-UV)
  - **Josép V. Sala** (SIUV)
  - **Gabriel Aparicio** (SIUV)
  - **Alejandro J. Soriano** (SIUV)
- **Students:**
  - **Carlos Cuesta** (UV)

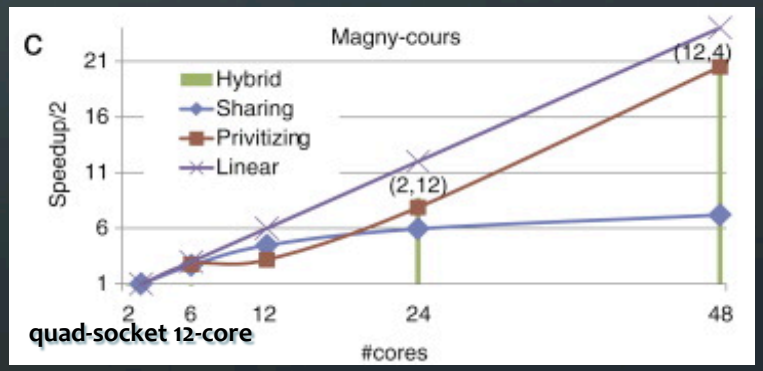
Universidad de Valencia

Technical improvements





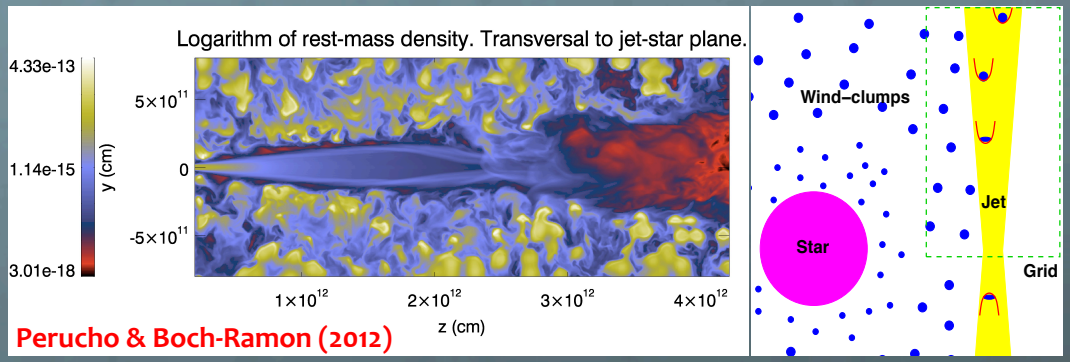




Code optimization/parallelization:

- Improved OpenMP/MPI version of `MRGENESIS` and `RATPENAT` and SPEV.
- Improvement as a result of the collaboration with the BSC and use of HPC analysis tools such as PARAVER.
- Improvement as a result of the collaboration with the UM and computer scientist hired under this CONSOLIDER (Tabik et al. 2012).

Scientific Applications



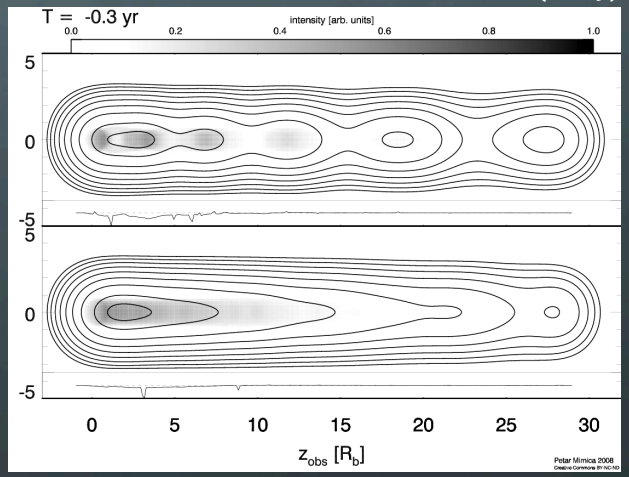
Perucho & Boch-Ramon (2012)

Microquasars:

The low statistics of microquasar jets in high mass microquasars may be due to the strong interaction with stellar winds. If $L > 10^{37}$ erg/s, jets could be able to propagate to observable regions, outside the binary-star region.

Code: **RATPENAT**. (Mare Nostrum).

Mimica et al. (2009)



Mergers of magnetized Neutron stars

Two neutron stars merge forming a hyperaccreting black hole and form a γ-ray burster.

Code: **Whisky + Carpet** (Mare Nostrum).

NASA press release (http://www.nasa.gov/topics/universe/features/gamma-ray-engines.html)

Rezzolla et al. (2011)

Radiative signature of relativistic plasma

MRGENESIS/SPEV 4D simulation of the radio emission of pc-scale jets.

Improved algorithm and parallelization pushed the performance x 1000.

Code: **MRGENSIS + SPEV** (Mare Nostrum).

Benefits from participating in SyeC

Computational time allocated to the members of the group:

- DECI-9 proposal "SpEcBNS": *granted access (2012/13) to the Tier-1 supercomputing infrastructure PRACE-2IP* (2.500 khr)
- AECT-2012-2-0007: *Building an improved catalog of gravitational waves from neutron star mergers* (800 khr)
- AECT-2011-1-0007: *Signatures of magnetic fields in relativistic jets of blazars and gamma-ray bursts* (200 khr)
- AECT-2011-1-0002: *On the stellar wind-jet interaction in high-mass microquasars* (500 khr)
- AECT-2010-2-0006: *Explaining blazars and GRBs with numerical relativistic ideal and resistive MHD* (900 khr)
- AECT-2010-1-0005: *Numerical study of magnetic reconnection in resistive relativistic MHD* (750 khr)
- AECT-2009-3-0005: " " " " " " " " " (1250 khr)
- AECT-2009-2-0008: " " " " " " " " " (1250 khr)
- AECT-2009-1-0003: *Effects of energy looses in relativistic jets* (300 khr)
- AECT-2008-3-0009: *Explaining blazars and GRBs with numerical relativistic MHD* (900 khr)
- AECT-2008-2-0010: " " " " " " " " (500 khr)
- AECT-2008-1-0014: " " " " " " " " (250 khr)
- AECT-2008-1-0007: *MHD instabilities in compact objects* (200 khr)

Contracts financed under the CSD2007-00050:

- Dr. Petar Mimica. Senior Postdoc. Until April 2011: MPI parallelization + parallel I/O (HDF5).
- C. Aloy. Computer scientist. April 2011 – October 2012: hybrid parallelization.
- J.E. Adsuara. Computer scientist. From October 2012: Paramul.

Assistance to Seminars and Courses:

- PUMPS Summer School: Organized by BSC, UPC, Uni. Illinois, HiPEAC. Jul 5 -9, 2010 (Barcelona).
- EuroMPI 2010: Organized by HLRS, Uni. Sttutgart. Sep 12 -15, 2010 (Stuttgart).
- PRACE Autumn School: Organized by BSC, UPC. Oct 25 - 29, 2010 (Barcelona).
- Cluster Management software and introduction to Infiniband technology: Organized by BSC, RES. May, 2011 (Barcelona).
- PRACE Summer School, Taking the Most Out of Supercomputers: Organized by CSC. Aug, 2011 (Espoo-Finland).
- Euro MPI Conference 2012: Organized by Vienna University of Technology. Sep., 2012 (Vienna-Austria).
- 7th Heidelberg Summer School on Computational Astrophysics: Organized by IMPRSS. Sept., 2012 (Heidelberg-Germany).

Other activities

Organization of international conferences and workshops

- **SEA 2012**: Organized by UV. July 9 -13, 2012 (Valencia). Session on Instrumentation and Computing and plenary talks on Computational Astrophysics.
- **Frontiers on GRID and Supercomputing**: Organized by IVICFA and UV. Oct 5, 2012 (Burjassot).
- **V Users Meeting of the RES**: Organized by BSC and UV. 26-11-2011 (Burjassot).
- **ASTRONUM-2011**: Organized by CSPAR, UAH, CEA/CNRS and UV. Jun 13 -17, 2011 (Valencia).
- **CoCoNuT meetings 2008-2012**: Organized by Obs. Paris, MPA, and UV. (Garching, Valencia, Paris. Palma).

Public Outreach:

- ***Creando Universos virtuales: Supercomputación en Astrofísica***, Ibáñez, Aloy & Quilis, Mètode, 64, 91 (2010)
- **Facebook pages:**
  - ✓ https://es-es.facebook.com/astrorela
  - ✓ https://es-es.facebook.com/pages/Computer-Aided-Modeling-of-Astrophysical-Plasma/311737045527633