3D simulations of sGRB jets: ballistic regime and afterglow emission

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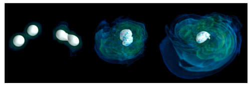
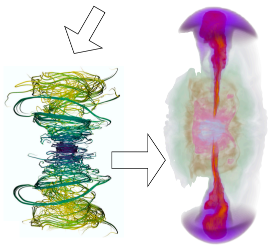
INTRODUCTION

1. Binary neutron star mergers can form a compact object (e.g. accreting black hole) able to launch relativistic jets
2. The jet, breaking out of post-merger environment, keeps evolving until reaches the ballistic regime (saturation of velocity and structure)
3. Powerful jets can produce a gamma-ray burst. Later interaction with the interstellar medium leads to the afterglow signal, which contains information on the jet structure



Binary neutron star merger



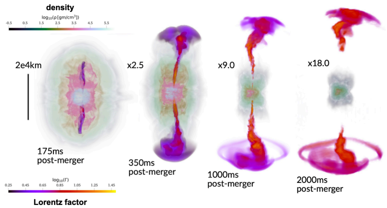
Jet formation   Jet break-out

SCIENTIFIC GOAL

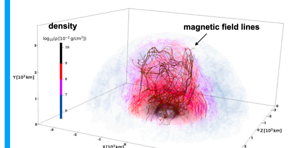
- Combine simulations of the merger process, jet break-out and jet propagation up to a quasi-ballistic regime in the first consistent end-to-end description.
- Connect the afterglow emission with the progenitor system and jet injection parameters.

JET INJECTION AND BREAKOUT

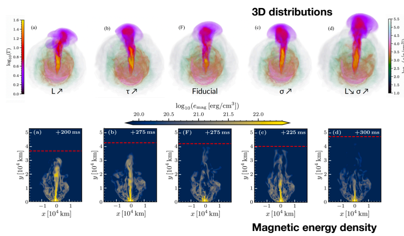
A magnetised jet is manually injected in a realistic post-merger environment, directly imported from the binary neutron star merger simulation of [1].



The study considers different injection parameters, such as the jet luminosity, magnetisation and launching time, investigating the effects on the following jet evolution and dynamics [6].

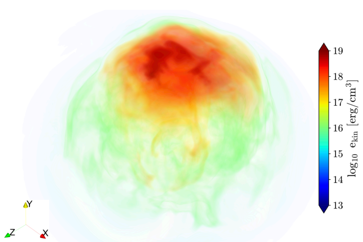


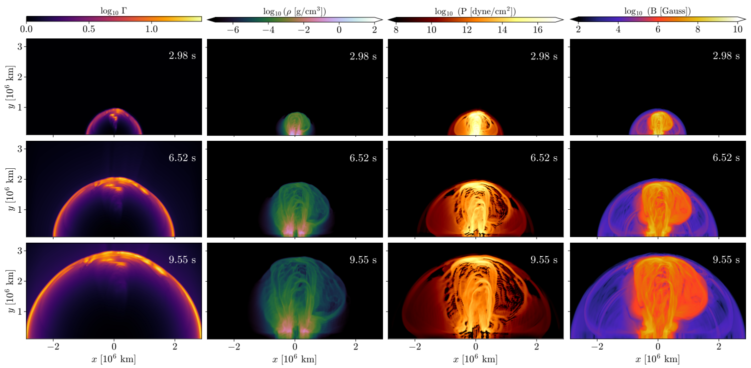
The jet is evolved in a spherical grid with the PLUTO code ([2]) for 3 s. The jet-environment interaction determines the break-out dynamics and the final angular structure and energetics [3,4].



LATE EVOLUTION AND BALLISTIC PHASE

- **Aim**: Follow the subsequent jet evolution without loss of resolution up to a quasi-ballistic regime.
- **Method**: Remap the output of the early evolution on a Cartesian grid with uniform cells, presented in Dreas et al. ([5]).

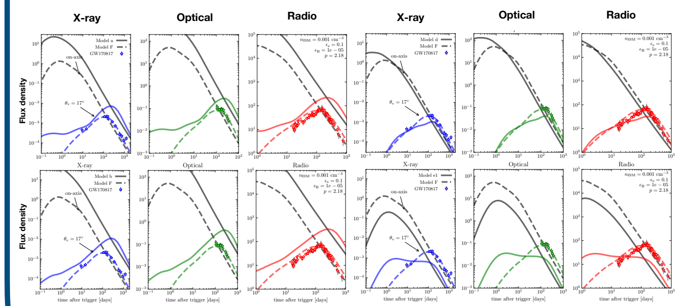




At the end of the simulations (tens of seconds), at least 94% of energy is converted into kinetic form and the angular structure is no longer changing. Strong deviations from axisymmetry are observed ([5,7]).

AFTERGLOW

We use the simulation outputs in semi-analytic afterglow models to produce light curves, to constrain the jet parameters through the comparison with observations (e.g. GRB 170817A).



Example of angle dependent multi-band jet afterglow light curves

- The structure and power of the jet influence the shape and intensity of the afterglow emission.
- A study is ongoing to fit the predictions of the set of jet simulations to observational data

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