Short GRBs: reaching jet quasi-ballistic regime and afterglow emission

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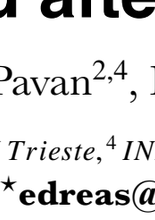
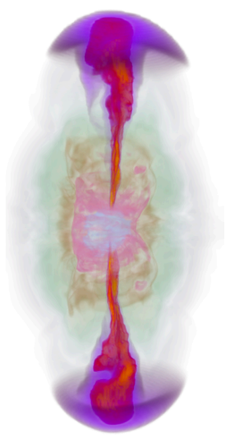
CONTEXT

- Binary neutron star (BNS) mergers can form compact objects able to launch relativistic jets, presumably responsible for short-GRBs
- After the break out in the post-merger environment, a jet evolves until it reaches a ballistic regime (saturation of velocity and structure)
- Later interaction with the ISM leads to the afterglow signal
- The jet evolution details are imprinted in the electromagnetic emission

Binary neutron star merger



Jet formation

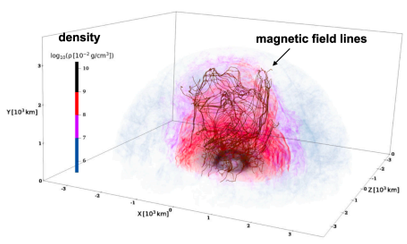


Jet break-out

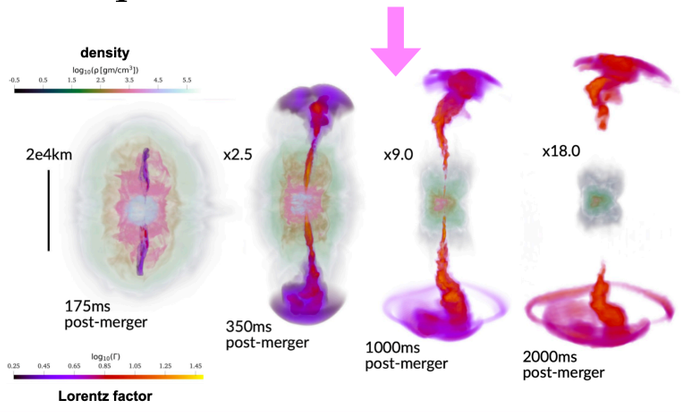
TOWARDS

- Combining simulations of the merger process, jet launching and propagation up to a quasi-ballistic regime
- Estimating the dependence of the afterglow emission on the progenitor system and jet injection parameters

STARTING: JET INJECTION



- A magnetized jet, with "ad hoc" initial conditions, was launched in a realistic post-merger environment imported from the BNS merger simulation by [1]
- The jet was evolved in a spherical grid with the PLUTO code [2] for ~ 3 s, following its angular dependent structure and energetics [3,4]

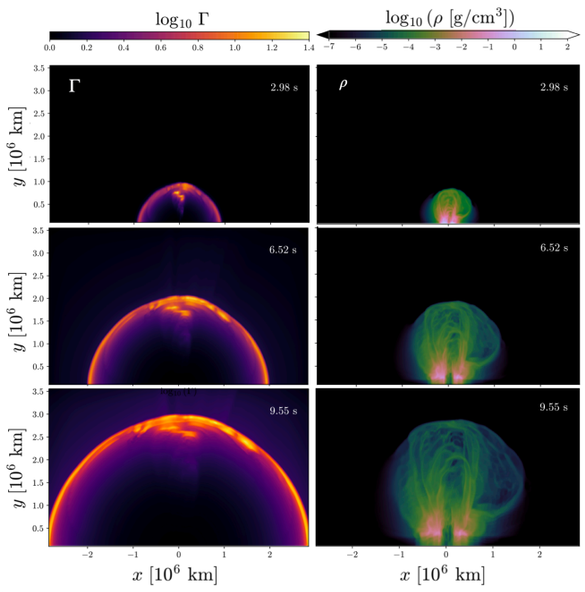


REACHING A QUASI-BALLISTIC REGIME

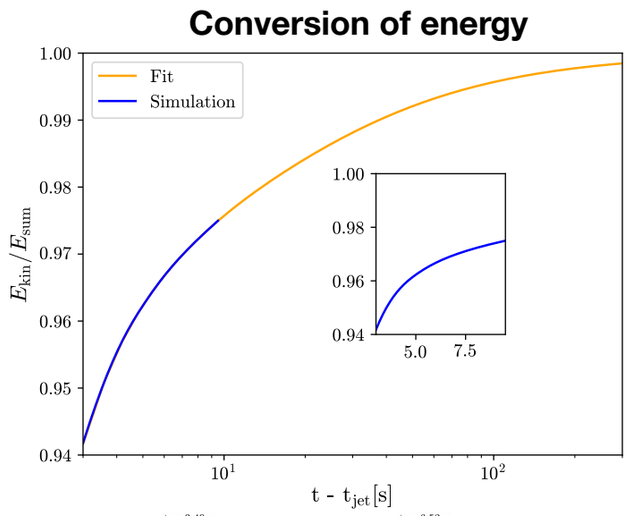
- **Aim of this work**: Follow the jet evolution without loss of resolution up to a quasi-ballistic regime with PLUTO to provide the input for the afterglow emission estimate

Lorentz factor **density**

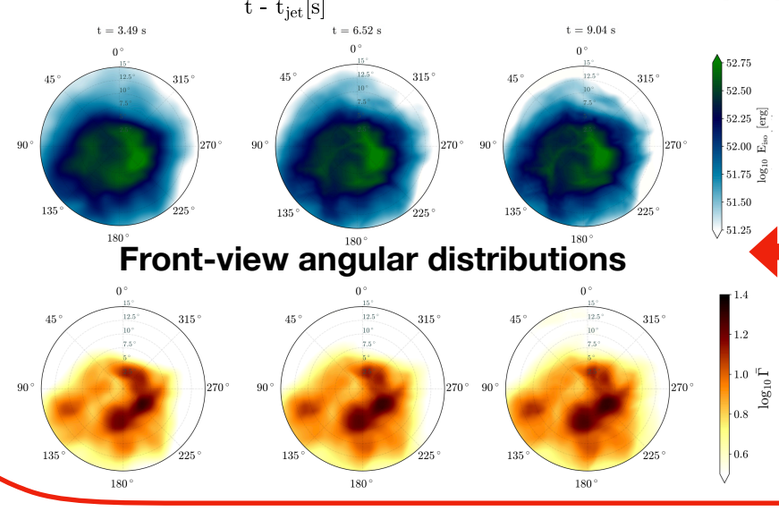
- **Method**: Re-map the output of the early evolution onto a Cartesian grid with uniform cells, generally applicable to similar numerical simulations



- **Main results**:



- At the end of the simulation (~10 s), 98% of energy is converted into kinetic form and the angular structure is no longer changing

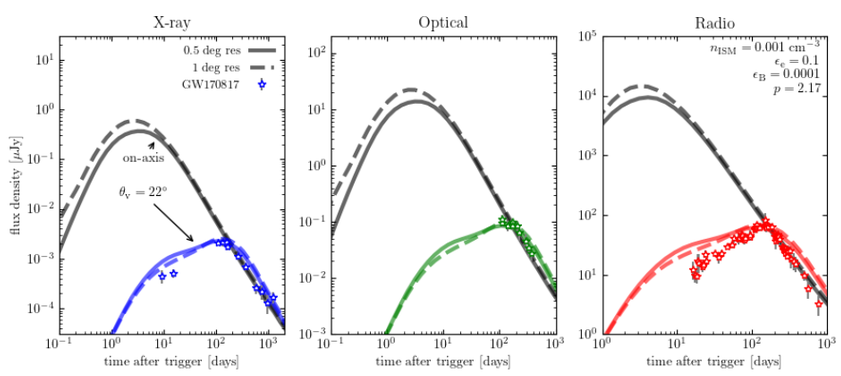


- Clear deviations from axisymmetry

OUTLOOK

- Systematic application to a set of short GRB jet initial parameters, linking the final jet structure with injection and break-out conditions
- Use the outputs in semi-analytic afterglow models to produce lightcurves and compare with observations (e.g. GRB 170817A)

Angle dependent multi-band jet afterglow light curves



Credits: O.S. Salafia

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[3] Pavan et al. (2021), MNRAS 506, 3483 524, 260;
[4] Pavan et al. (2023), MNRAS; 524, 260; [5] Dreas et al. (2024), A&A, submitted

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