(Time-Domain and Multimessenger) TDAMM SIG

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TDAMM and APS

Sources

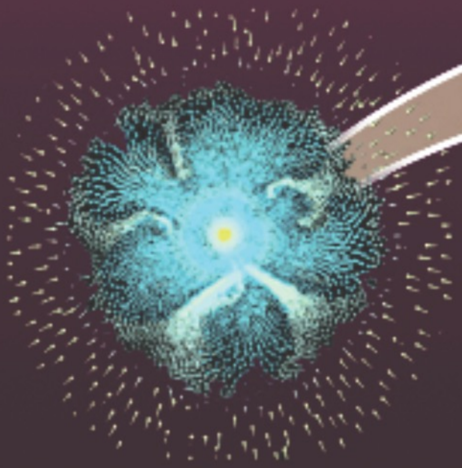
- Neutron star mergers
- Core-collapse supernovae
- Blazars
- Type Ia supernovae
- Fast radio bursts
- Type I X-ray bursts
- Collapsars
- Magnetars
- Binary black hole mergers
- Etc

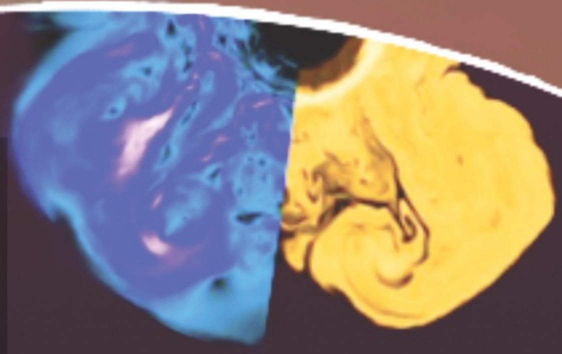
Disciplines

- Astrophysics (DAP)
- Gravity Physics (DGRAV)
- Nuclear Physics (DNP)
- Atomic, Molecular Physics (DAMOP)
- Condensed Matter (DCMP)
- Plasma Physics (DPP)
- Particle Physics (DPF)
- Computational Physics (DCOMP)
- Fluid Dynamics (DFD)
- Fundamental Physics

C. Fryer, E. Burns, et al. submitted to ApJ; Image credit: Michela Negro (GSFC)

Understanding Core-Collapse Supernovae





CCSN Phase
Followups / studies
- Diagnostics
  Observables

WHAT WE NEED TO KNOW:
- ✓ Condensed matter
- ✓ Neutrino physics
- ✓ General Relativity
- ✓ Magnetohydrodynamic
- ✓ Plasma Turbulence
- ✓ Nuclear physics
- ✓ Cosmic-ray acceleration
- ✓ Radiation transport
- ✓ Chemistry of Galactic dust

Phase I – Core collapse

Radio followup (pulsars)
X-ray followup (binaries)
Multimessenger detections

- Prompt emission
  Gravitational waves
  MeV Neutrinos
- Compact remnants
  Mass and spin (through GW, radio and X-ray observations)

Phase II – Propagation of the blastwave through the star

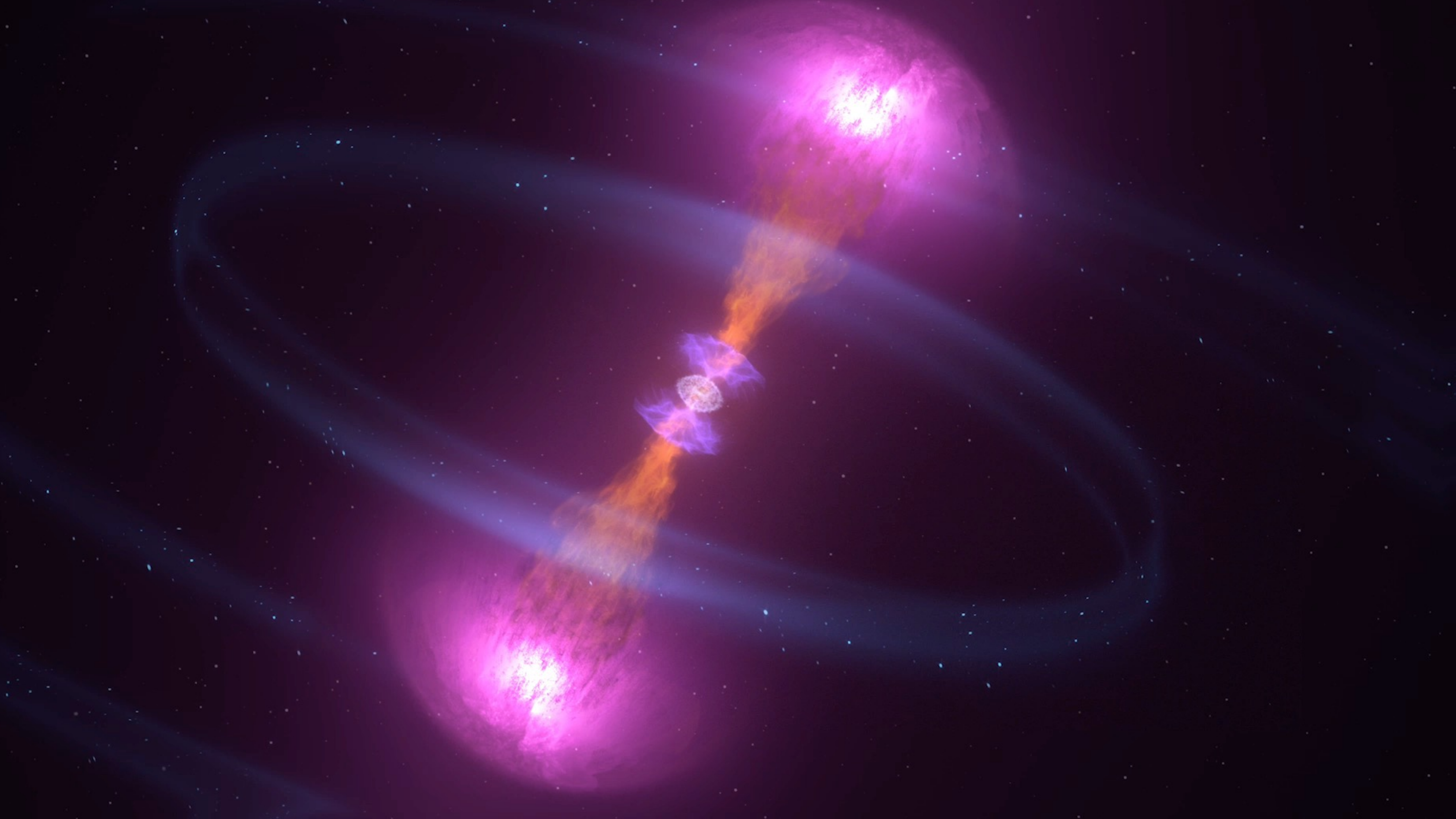
EM followup for stellar abundance patterns
Dust study (in lab and with SN observations)

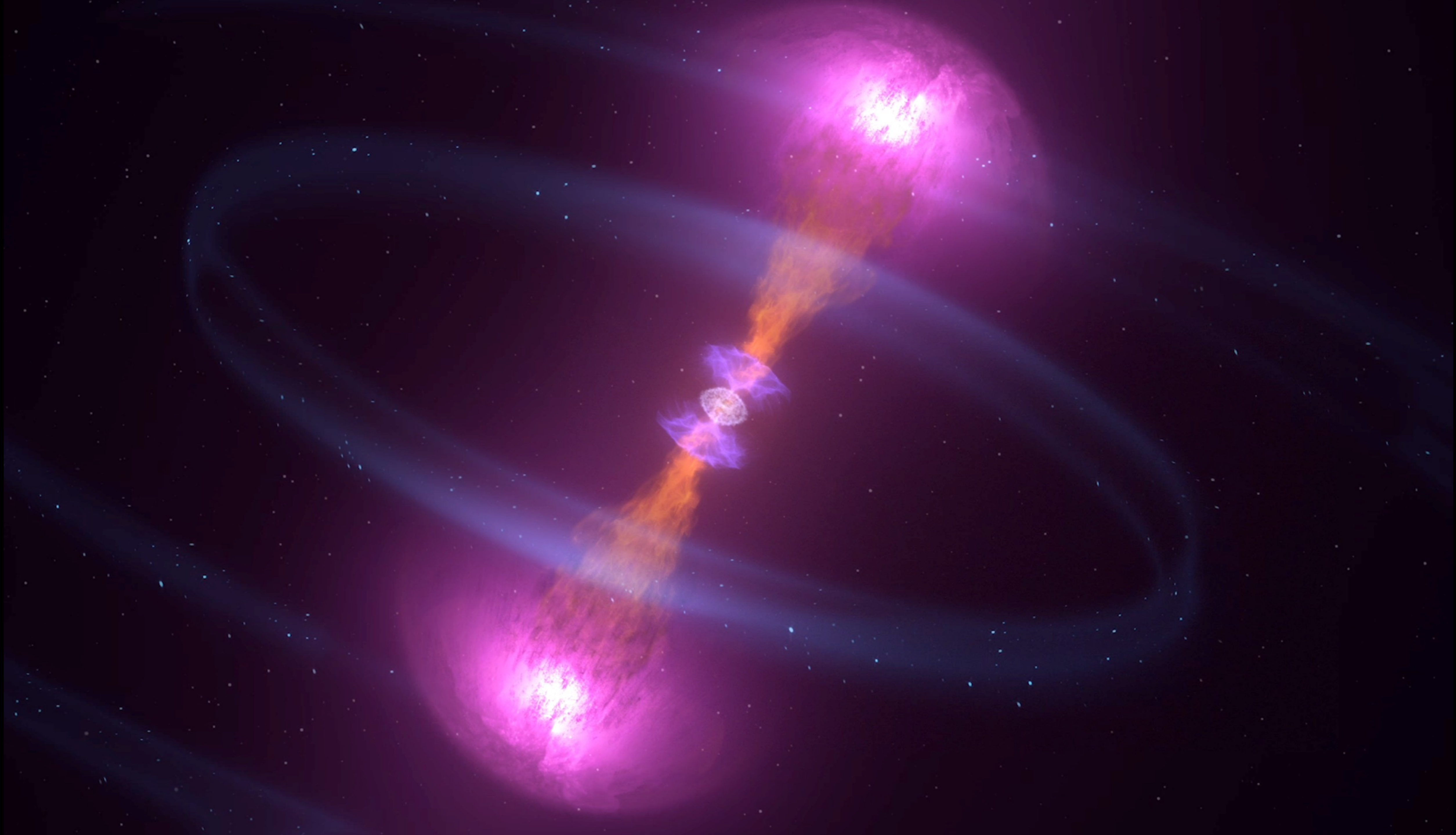
- Shock breakout
  UVOIR and X-ray light curves, spectra
- Nucleosynthetic yields
  Galactic dust composition
  Galactic chemical evolution

Phase III –Propagation of the blastwave through the circumstellar medium

Broad band followup (Radio – gamma-ray)

- Temporal evolution of emitted radiation
  Light curves and spectra
- Supernova remnant
  Light curves, spectra (lines)
  Imaging of morphology (asymmetric explosions)
  Polarimetry (magnetic fields structure)





Origin of the Heaviest Elements

Current limitations
- Separation of merger, kilonova simulations
- Atomic opacities
- Nuclear physics, reaction networks
- Ionization
- Neutrino transport
- Velocity gradients
- Magnetic fields
- Entropies
- Thermalization efficiencies
- Grid formulations/resolutions
- Neutron star equation of state
- Inclination effects
- Non-local thermal equilibrium / electron transport
- Etc

Conflating issues
- Afterglow contamination
- Magnetar-driven winds
- Free neutron decay
- Interactions of jet with kilonovae material

Reasons for hope
- FRIB
- New atomic opacities in NIST database
- Continued advancement in simulations
- Priority science this decade
- NICER NS EOS constraints
- More multimessenger detections coming
- ULTRASAT
- Etc

- Electromagnetic and strong nuclear force are parity-conserving
- The weak nuclear force is, surprisingly, 100% parity-violating
- What about gravity?

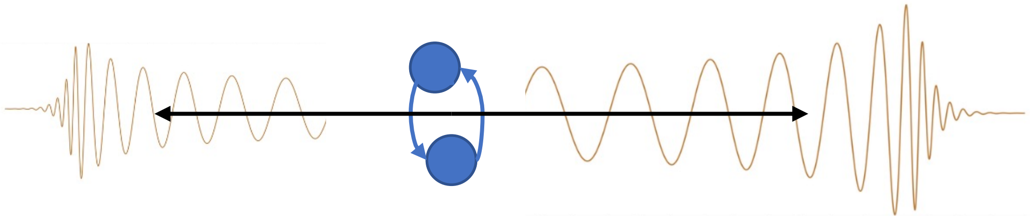
  - General relativity is parity conserving
  - Parity-violating gravity reduces to Chern-Simons gravity
  - CS gravity could explain matter excess over antimatter, dark matter through alps, step towards GUT
  - Likeliest explanation for asymmetry in galaxy distributions (Alexander et al. 2023, in prep)

- Cahn et al. 2021 arXiv:2110.12004
- Philcox 2022 arXiv:2206.04227
- Hou et al. 2022 arXiv:2206.03625

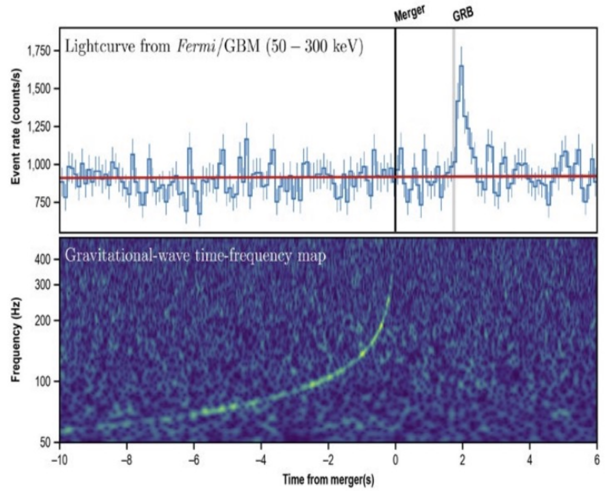
Parity Violation

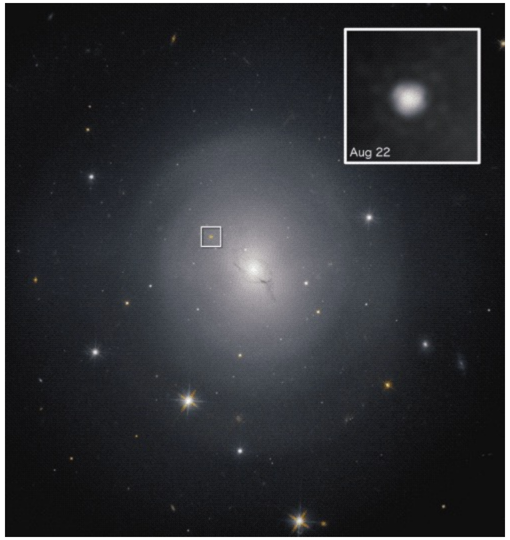
Test requires high GW-GRB rates, successful follow-up. Enhanced by afterglow studies

On-going work: Leah Jenks, Nico Yunes, EB

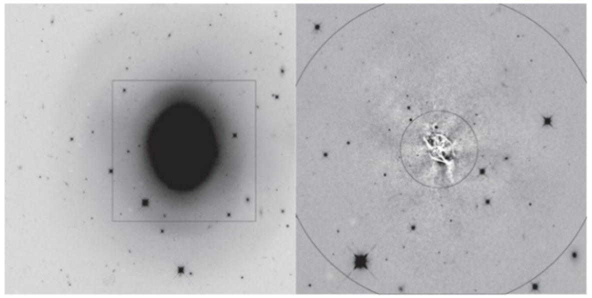


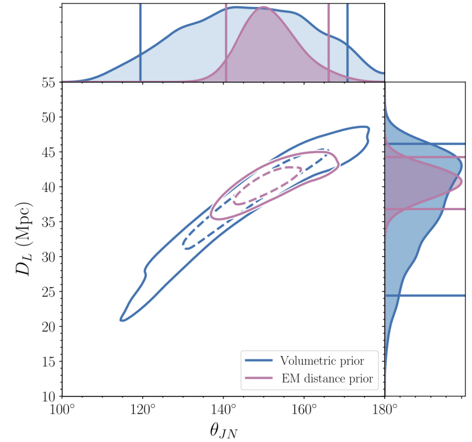
1. Left handed polarization enhanced, right-handed suppressed (or vice versa). Face-on events will be pure left or right.



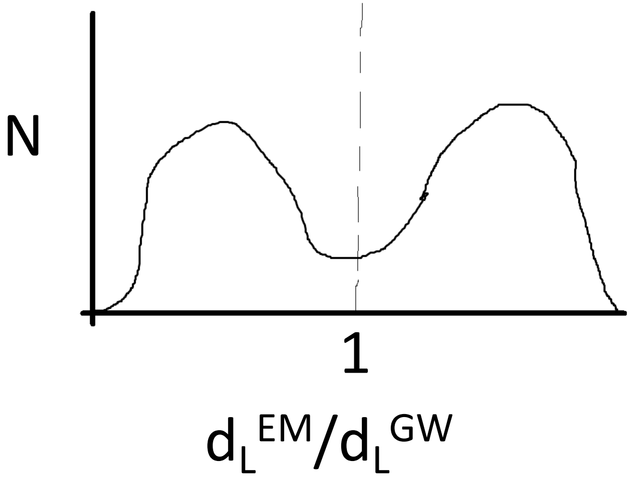


2. Detect in GW and gamma-rays. Recover in follow-up. Associate to host.





3. Infer distance from EM-only and GW-only observations



4. If parity is violated, d_L^{EM} and d_L^{GW} will disagree. Do this for a population and you get the left figure.

TDAMM SIG

Community building for TDAMM

- Attempt to engage with physicists who do not traditionally join NASA's community efforts
- Foster understanding of different disciplines – ideally an APS role

Usual SIG responsibilities

- Create SAGs for reports on specific topics
- Set technology gaps for strategic funding
- Organize sessions at conferences, virtual meetings
- Report to APAC