Dates:

Jul 16, 2012 - Oct 12, 2012

Application Information:

Apply [1]

Application deadline is:
Aug 30, 2011

Quick Links:

Chirps, Mergers and Explosions:

The Final Moments of Coalescing Compact Binaries

Coordinators: Edo Berger, Duncan Brown, Alessandra Buonanno, Chris Fryer, Luis Lehner

The direct detection of gravitational waves, and their association to electromagnetic counterparts, would be a transformative event in 21st century astrophysics. The most promising sources for detection with the next-generation gravitational-wave detectors (Advanced LIGO and Virgo in 2015) are compact object binaries, containing neutron stars and/or black holes. When matter is present, these sources are also expected to produce brilliant electromagnetic fireworks (for example, short-duration gamma-ray bursts), which will aid in the detection, localization and interpretation of the gravitational-wave signals, as well as in the extraction of source physics. The aim of this three-month program is to address the wide range of analytical, numerical, and observational questions related to the evolution of these systems and their associated gravitational-wave and electromagnetic signatures, and to discuss optimal strategies for their detection. Overlapping participation from the relevant communities is sought, in order to pursue a fundamental understanding that includes detailed waveform predictions, detectability in gravitational and electromagnetic waves, and coordination of the observational searches.

The primary goal of this program is to address the inspiral and merger physics of various binary systems, to study the merger signatures in gravitational waves, and to explore the electromagnetic outcomes. These goals will be addressed concurrently around the main themes of detection (gravitational waves and electromagnetic), measurement of source properties (mass, spin, distance), and interpretation (evolution, general relativity, cosmology). The program will also include a week-long conference (July 30 - August 3, 2012) on the topic of gravitational wave and electromagnetic studies of compact object binaries.

http://www.kitp.ucsb.edu/activities/dbdetails?acro=chirps12

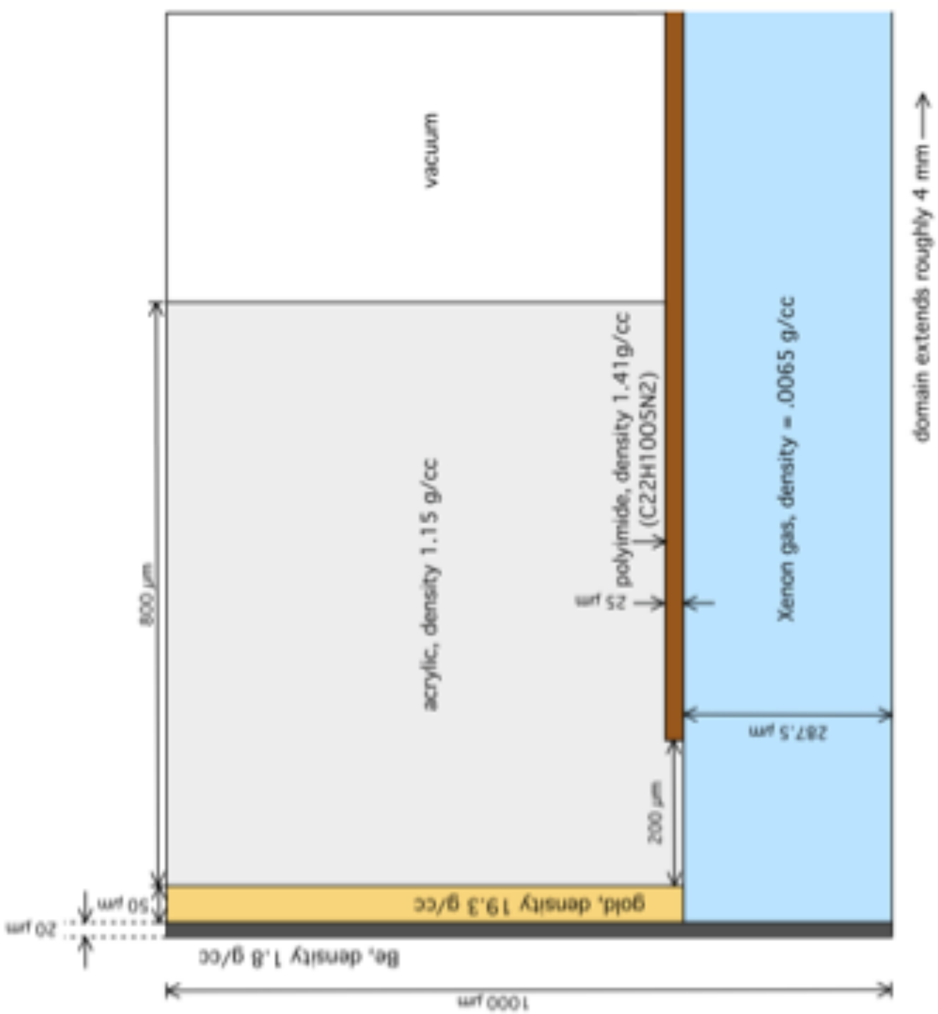
NS/BH Transients as Nuclear Physics Experiments

Chris Fryer

- Laboratory Experiments
- Available NS/BH Transient experiments
- Available Diagnostics

Transients as Nuclear Physics Experiments

U Michigan CRASH experiment

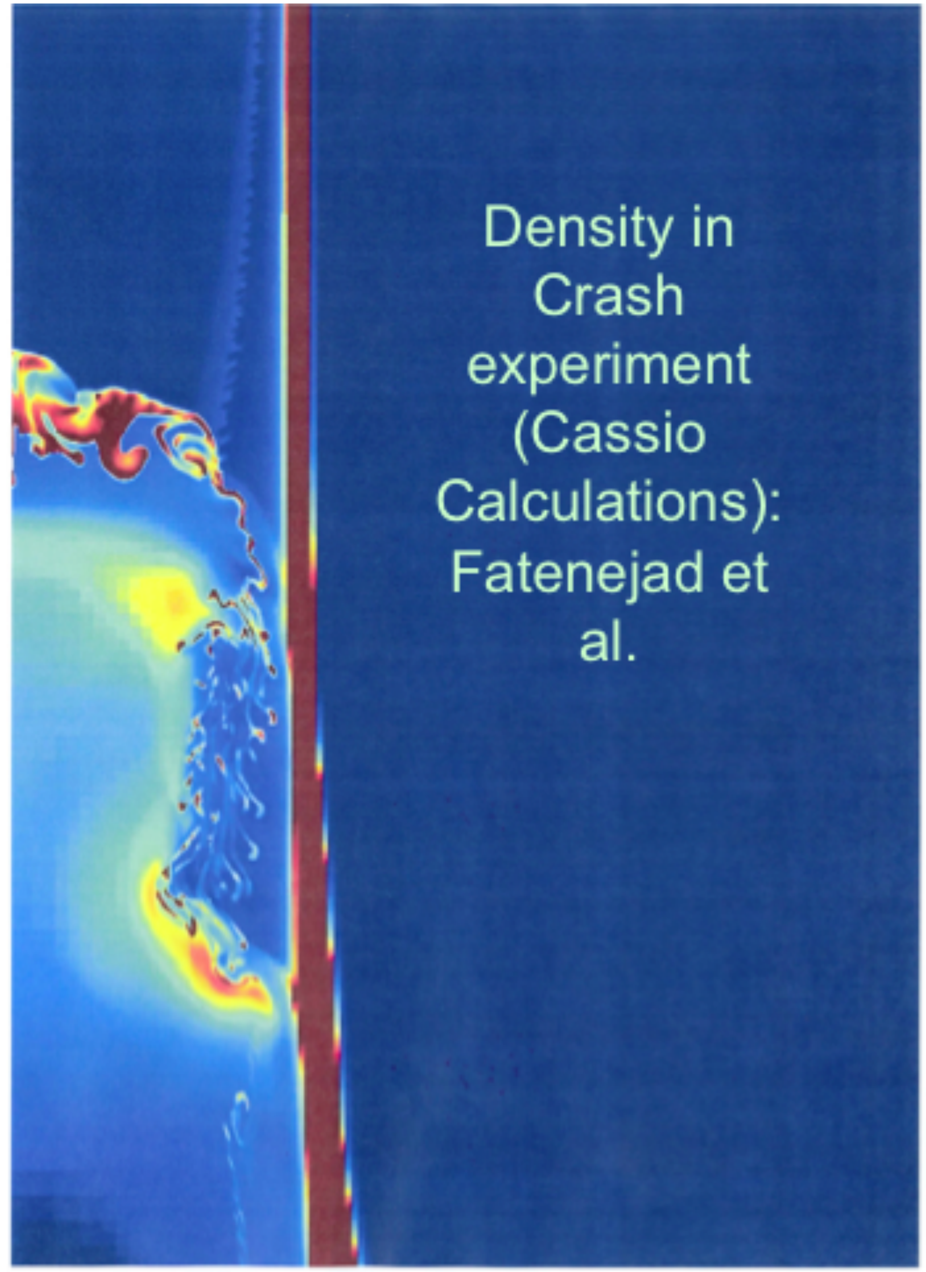


Uncertainties in initial conditions:

- initial perturbations
- exact composition
- drive luminosity

Using experiments to constrain physics/ code is difficult. Multiple uncertainties drive errors:

- EOS and opacity uncertainties
- Modeling constraints: limitations of 2D, missing physics
- Modeling diagnostics correctly



Neutron Star Transients (Progenitors/Engines)

Collapse Powered

- Normal Supernovae
- Fallback SNe – Faint supernovae, XRF?
- Magnetars – special supernovae, GRBs?
- Collapsar – GRBs
- Low-Mass Supernovae
- Accretion Induced Collapse: WD/WD mergers, ONe WD accretion

Accretion Powered

- NS/NS, NS/BH mergers - GRBs
- NS/BH mergers with companion (He-star mergers) – XRF?, GRBs
- WD/BH or WD/NS mergers – XRFs, GRBs???
- X-ray bursts and Superbursts
- Type II bursts
- Superfast X-ray transients
- Tidal disruption of star onto BH: AGN flares
- Minor bodies on NSs

Other

- Neutron Star Cooling
- NS quakes – could make smaller SGRs
- Magnetar flares - SGRs

Diagnostics

- Photons
  - Optical/IR: Explosion and Remnants, inclination in X-ray bursts
  - X-ray: shock breakout, shock/environment interactions (GRBs, XRF), hot outbursts and disks (like X-ray bursts), remnants
  - Gamma-rays (jets, radioactive decay – yields)
- Cosmic Rays (particle acceleration in jets, remnants, NS magnetic fields)
- Nucleosynthetic yields: observed in spectra from IR to gamma-rays as well as integrated yields in stars and asteroids
- Gravitational Waves: Rotation and Instabilities in core (SNe), Merger progenitors
- Neutrinos: Core (Collapse Engines)

Normal Supernovae

- Assuming the instability-enhanced engine is correct, different models (different dominant instabilities, rotation, fallback) make different predictions for neutrino and gravitational wave signals.
- Growing set of progenitor observations
- Light-Curves and Spectra constrain ejecta mass, some yields (how much?), energy and asymmetry.
- X-rays can add progenitor constraints (stellar radius, immediate environment) as well as energy, ...
- Remnants can add strong yield constraints as well as energy, ...
- For a nuclear physics experiment, I see the goal being to use the wealth of observations to constrain the explosion so that we can use neutrino and GW signals to probe nuclear physics.
- Can we probe EOS at nuclear densities or neutrino physics without a neutrino or GW diagnostics?
- For some neutrino physics and nuclear rates, we can!

Other Engines

- Fallback Supernovae: Can models of fallback (constrained by observed explosion) allow us to probe neutrino physics? Black hole formation!
- Accretion Induced Collapse – simpler engine and minimal (negligible) fallback allow us to more directly use neutrinos to probe nuclear physics. Potential fast rotation make these exciting GW sources (good diagnostic of GWs).
- GWs from DNS or BH/NS merger can be seen at high distances and measure chirp mass accurately for point masses: $M \equiv (M1\ M2)^{3/5} (M1+M2)^{-1/5}$, current effort is focused on studying EOS in the mergers (but if the SN field is any indication, this might be difficult). What about at the onset of tidal effects?
- X-ray bursts – clear potential in constraining NS radii. Can we do this with 1D models and simple transport?
- Collapsars, Magnetars, He-mergers all depend on magnetic fields – we are a ways from predicting anything here. Cosmic rays provide insight.

Sensitivity ($d_{0,nsns}$=)	Type	$Z_\odot$ (100%)	0.1 $Z_\odot$ (100%)	$Z_\odot$ + 0.1 $Z_\odot$ (50% + 50%)
4*18 Mpc	NS-NS	0.01 (0.003)	0.01 (0.001)	0.01 (0.002)
	BH-NS	0.007 (0.00002)	0.04 (0.02)	0.02 (0.01)
	BH-BH	0.02 (0.00005)	9.9 (0.1)	4.9 (0.05)
	Total	0.03 (0.003)	10.0 (0.1)	5.0 (0.06)
4*45 Mpc	NS-NS	0.2 (0.05)	0.2 (0.01)	0.2 (0.03)
	BH-NS	0.1 (0.0003)	0.5 (0.3)	0.3 (0.15)
	BH-BH	0.3 (0.0007)	145.4 (1.6)	72.8 (0.82)
	Total	0.6 (0.05)	146.1 (1.9)	73.3 (1.0)
4*97 Mpc	NS-NS	1.5 (0.5)	1.6 (0.1)	1.5 (0.3)
	BH-NS	1.0 (0.003)	4.8 (2.9)	2.9 (1.5)
	BH-BH	2.8 (0.007)	1454.6 (16.4)	728.7 (8.2)
	Total	5.3 (0.5)	1461.0 (19.5)	733.2 (10.0)
4*300 Mpc	NS-NS	44.3 (15.1)	45.9 (4.0)	45.1 (9.5)
	BH-NS	29.7 (0.1)	141.9 (85.4)	85.8 (42.8)
	BH-BH	82.4 (0.21)	42768.0 (483.3)	21425.2 (241.7)
	Total	156.4 (15.2)	42955.8 (572.7)	21556.0 (294.0)

Belczynski et al. 2010

Science Goals

- Classifying Objects
- What are these objects?
- What do we need to understand these objects?
- What can we learn from these objects?
  - Turbulence
  - Plasma and atomic physics
  - Nuclear cross-sections
  - Nuclear and Neutrino physics
  - Relativity