INTERACTION OF BLACK HOLES AND NEUTRON STARS

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Brief Overview

- Black Holes and Neutron Stars
- Gravitational Waves and Gamma-Rays
- General Relativity/Methods
- Purpose of Research
- Research Goals
Life Cycle of a Massive Star

- Red Supergiant
- Supernova
- Black Hole
- Neutron Star
- Recycling
- Nebula
Black Holes and Neutron Stars

Formation: massive star collapse – Supernova!!

<table>
<thead>
<tr>
<th></th>
<th>Black Hole</th>
<th>Neutron Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>&gt;3 solar masses</td>
<td>1.4~3 solar masses</td>
</tr>
<tr>
<td>Density</td>
<td>∞</td>
<td>$2\sim4 \times 10^{14}$ times $\rho_{\text{sun}}$</td>
</tr>
<tr>
<td>Escape Velocity</td>
<td>∞</td>
<td>33% speed of light</td>
</tr>
</tbody>
</table>
Black Hole Geometry

Event horizon

Singularity
Gravitational Waves

- What they are – in theory?
- Why do we care?
- What do we think will create them?
- How do we detect them?
- LIGO (Laser Interferometer Gravitational Wave Observatory)
Gamma-Rays

- Long Gamma-Ray Bursts vs. Short Gamma-Ray Bursts (SGRB)

- SGRB mechanisms: NS-NS collision, BH-NS encounter

- Most energetic events in universe
General Relativity

- Why we need to consider it?
- Curvature of Space-time
- Einstein Toolkit / Cactus
Project Goals

Black Hole – Black Hole:

1) Will two black holes in parabolic orbit create gravitational waves that are detectable?

2) Depending on the size, how far away can we detect gravitational waves?
Project Goals

Neutron Star – Black Hole:

1) Will the neutron star form an accretion disk around the black hole?

2) Will this disk survive as long as the duration of observed SGRBs?
Initial Conditions

Initial Configuration

<table>
<thead>
<tr>
<th></th>
<th>Black Hole – Black Hole</th>
<th>Black Hole – Neutron Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass 1 (solar masses)</td>
<td>0.5</td>
<td>4.51</td>
</tr>
<tr>
<td>Mass 2 (solar masses)</td>
<td>0.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Initial separation (km)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Periastron distance (km)</td>
<td>2.21</td>
<td>20.1</td>
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</tbody>
</table>
## Initial Conditions

### Results:

<table>
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<tr>
<th></th>
<th>Black Hole – Black Hole</th>
<th>Black Hole – Neutron Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>x-position (km)</td>
<td>Mass 1 50</td>
<td>Mass 2 -50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass 1 24</td>
</tr>
<tr>
<td>v_x (m/s)</td>
<td>-2.55*10^7</td>
<td>2.55*10^7</td>
</tr>
<tr>
<td>v_y (m/s)</td>
<td>3.84*10^6</td>
<td>-3.84*10^6</td>
</tr>
<tr>
<td>v_total (m/s)</td>
<td>2.58*10^7</td>
<td>2.58*10^7</td>
</tr>
</tbody>
</table>
Upcoming Weeks

- Setup Parameter File
- Start Simulations
- Hope for the best
- Fix errors and rerun
- Adjust initial conditions based on results of first simulations
Works Cited

Illustrations:


