THE EFFECT OF METALLICITY ON THE DETECTION PROSPECTS FOR GRAVITATIONAL WAVES

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METALLICITY FACTORS

• High amount of metals increases opacity which makes the stars more puffy

• Higher opacity also increases radiation driven mass loss

• During expansion stars with higher metallicity experience larger radius changes
$M_{\text{zams}} = 30\, M_\odot$

$Z = Z_\odot$

$Z = 0.1\, Z_\odot$

$R\left[ R_\odot \right]$ vs $t\left[ \text{Myr} \right]$. 

HG
BINARY STAR EVOLUTION

- Supernovae
  - Kick magnitude is dependent on pre-SN core mass – more mass $\Rightarrow$ weaker kicks
  - Strong kicks may disrupt a binary system, preventing future merger

- Common envelope
  - Insufficient orbital energy – merger
  - Sufficient orbital energy – tight system
More likely to disrupt

Less likely to disrupt

Less likely to survive

More likely to survive
ESTIMATE OF THE RATE

- Metallicity: $Z_{\text{sun}}$ and $0.1Z_{\text{sun}}$
- Constant star formation rate (3.5 $M_{\text{sun}}$/yr)
- Merger rate for Milky Way
- Extrapolation to local Universe

$\text{SNR} \sim M^{5/6}/D$
<table>
<thead>
<tr>
<th>System</th>
<th>$Z_{\text{sun}}$</th>
<th>$0.1Z_{\text{sun}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-NS</td>
<td>14.4</td>
<td>3.3</td>
</tr>
<tr>
<td>BH-NS</td>
<td>0.01</td>
<td>7.0</td>
</tr>
<tr>
<td>BH-BH</td>
<td>14.4</td>
<td>16.4</td>
</tr>
</tbody>
</table>
## DETECTION RATES [yr⁻¹]

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Type</th>
<th>$Z_{\text{sun}}$</th>
<th>$0.1Z_{\text{sun}}$</th>
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</thead>
<tbody>
<tr>
<td>18 Mpc</td>
<td>NS-NS</td>
<td>0.003</td>
<td>0.001</td>
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<tr>
<td></td>
<td>BH-NS</td>
<td>0.00002</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>BH-BH</td>
<td>0.00005</td>
<td>0.1</td>
</tr>
<tr>
<td>300 Mpc</td>
<td>NS-NS</td>
<td>15.1</td>
<td>4.0</td>
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<tr>
<td></td>
<td>BH-NS</td>
<td>0.1</td>
<td>85.4</td>
</tr>
<tr>
<td></td>
<td>BH-BH</td>
<td>0.21</td>
<td>483.3</td>
</tr>
</tbody>
</table>
SUMMARY

• Lowering metallicity decreases supernova kicks and stellar radii ensuing increased survival rate of BH-BH binaries

• Reduced mass loss rates increase BH remnant masses, which should yield a stronger SNR

• BH-BH binary detection rates are up to 100 times larger than for NS-NS binaries

• Detailed waveform implementation, evolution improvement and cosmology calculations underway