Parameter Space Dependence of Junk Radiation in Binary Black Hole Simulations

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### Junk Radiation
- At early times in BBH simulations, non-astrophysical “junk radiation” (JR) is emitted
- Adds to computational cost
- Reduces accuracy of simulations
- Makes comparison with Post-Newtonian waveforms harder

![Junk radiation in a typical BBH simulation (followed by the inspiral waveform)](image)

### The Origin of Junk Radiation
BBH initial data does not perfectly capture the configuration that would come from a long inspiral
- Tidal Interactions are not accounted for (so JR should decrease with distance)
- Assumption of conformal flatness is typically used in initial data. \( g_{ij} = \psi^4 f_{ij} \). But...
  - Kerr space-time does not admit conformally flat slices \([1]\) (so JR should increase with spin)
  - Two compact objects are not conformally flat \([2]\) (so JR should have some kind of constant offset)

### Methods
- We quantify the dependence of junk radiation on distance and on spin
- Use distances from 12M to 30M and dimensionless spins from 0 to 0.5
- Simulations performed with Caltech/Cornell/CITA SpEC code\([3]\)
- Equal-mass, non-precessing binaries are used for simplicity
- Conformally flat, conformal thin sandwich initial data is used
- Junk Radiation quantified in three different ways:
  - Energy extracted from the system by junk radiation
  - Fractional mass change of a black hole due to junk radiation
  - Fractional spin change of a black hole due to junk radiation

### Results

#### Extracted Energy

![Power law (n~3) dependence on distance](image)

No significant dependence on spin

#### Fractional Mass Change

![Power law (n~1) dependence on distance plus a constant offset](image)

Almost exponential dependence on spin

#### Fractional Spin Decrease

![Power law (n~5.5) dependence on distance plus a constant offset](image)

Exponential dependence on spin. \textit{Note – This effectively limits the maximum possible spin to \sim0.92.}

### Future Work
- Compare with conformally curved initial data, such as superposed Kerr-Schild data \([4]\)
- Extend to spins higher than 0.5

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