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A discontinuous Galerkin method for the distributionally-sourced s=0 Teukolsky equation

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With the detection of first gravitational waves in 2015 by the laser interferometers at Laser Interferometer Gravitational wave Observatories (LIGO) located in Hanford and Livingston that was followed by a Nobel prize, there is an urgent need of more template waveforms for a bigger parameter space. The upcoming space borne detector Laser Interferometer Space Antenna (LISA) is primarily sensitive to Extreme Mass Ratio Inspirals (EMRI) where the mass ratio between two black holes lies between 10 to 10^7solar masses. LIGO uses a method known as match filtering where the detector tries to match the incoming signals with the existing waveforms simulated from Numerical Relativity (NR) or other numerical techniques. NR is only useful to model systems where the mass ratio is less than 10 as the problem becomes computationally expensive for larger ratios. Hence, there is a need to use a different method to simulate the EMRI systems. This is where Discontinuous Galerkin method comes into the play as it is the best suited for such kind of systems. It can incorporate the point particle behavior of the smaller black hole in the form of a delta function and due to the discontinuous nature of the scheme it is inherently highly parallelizable and thus generates highly accurate waveform in very short amount of time compared to the other methods. In this project, we intend to explore the application of discontinuous Galerkin method in the EMRI systems. We reduce the Teukolsky equation to a set of coupled 1+1D wave equations and apply the dG method to it with a delta source term, acting like the secondary black hole in an EMRI system.

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