Specific Research Tasks for Completion of PhD

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1. Examine stability of ADM code. Since this has a high eureka-factor it will be an ongoing investigation done in parallel with writing up chapters on stability of numerical methods and description of the ADM code.

a. Are there some other one-sided stencils which provide stable updates at the boundaries. *Don't spend too much time on this.*

b. What is the nature of the current problems with instabilities and oscillations in the ADM code–unstable updates, coordinate stretching problems, etc.

2. Boosted Kerr evolutions. This seems to be a worthy goal with several specific tasks which would contribute to the overall ADM code.

a. Previous version of the ADM code has Kerr ID and analytic setting of Kerr coordinates. The ADM code needs to be updated to accomodate a blending zone near the outer boundary.

b. Once the ADM code is updated, a survey of runs will be made to see how well the Kerr data evolves for various values of angular momentum.

c. Next a series of boosted Kerr runs will be accomplished to evaluate the behavior of the code. Also, a comparison will be made of boosted Kerr versus boosted Schwarzschild.

d. *Integrate flow-method Horizon tracker into boosted-Kerr runs.*

3. Use of non-zero constraint values as damping terms in the ADM code.

a. This first involves clarifying the theory a bit. There seems to be a difference of opinion over whether non-zero constraints are maintained by the G_{ij} form or the R_{ij} form of the evolution equations.

b. The ADM code has a module to monitor the momentum constraint errors. These modules will be turned on to allow assessment of Hamiltonian and momentum constraint error.

c. Hamiltonian Constraint. The first thing to try in the ADM code would be to add a term to the $dotK_{ij}$ equation proportional to $-\epsilon g_{ij} K H(check\ sign)$ to provide some damping to the growth in the Hamilitonian error.

d. If time allows, similar dissipative/damping terms can be explored using the momentum constraints.

4. Binary Black Hole problem. Before the binary black hole evolution can be run in high fidelity, we are awaiting the completion of the ID solver by Klasky and Carmada and the development of the new horizon tracker by Shoemaker. In the meantime the following tasks can be explored.

a. For the excision of the black holes, the ADM code uses both a characteristic function to discribe the excised grid points and a list to identify grid points on the surface of the excised region. This data structure will be examined to ensure it's compatible with binary black hole problems.

b. The causal differencing algorithm currently uses the location of a single black hole as a point of reference in it's computations. This algorithm will be explored/modified to ensure it's compatible with binary black holes.

c. Some preliminary runs will be accomplished using approximate initial data to experiment with the ADM code in the BBH mode. As modules are improved, runs of increasing fidelity and duration can be accomplished.