

# The Weak Null Condition in Free-evolution: Dual Foliation GHG with Constraint Damping

Edgar Gasperin, David Hilditch

Centro de Astrofísica e Gravitação - CENTRA,  
Departamento de Física, Instituto Superior Técnico - IST,  
Universidade de Lisboa - UL, Av. Rovisco Pais 1, 1049-001 Lisboa,  
Portugal

All strategies for the treatment of future null-infinity in numerical relativity involve some form of regularization of the field equations. In a recent proposal that relies on the dual foliation formalism this is achieved by the use of an asymptotically Minkowskian generalized harmonic tensor basis. For the scheme to work however, derivatives of certain coordinate light-speeds must decay fast enough. In this talk I will discuss how to generalize the method of asymptotic expansions for nonlinear wave equations to treat first order symmetric hyperbolic systems and how to exploit this heuristic tool to extract the expected rates of decay of the metric near null-infinity in a free-evolution setting. It will be shown that, within the asymptotic expansion, by carefully modifying the non-principal part of the field equations by the addition of constraints, it is possible to obtain optimal decay rates even when the constraints are violated. The light-speed condition can hence be satisfied, which paves the way for the explicit numerical treatment of future null-infinity. Additionally, the behavior of the Trautman-Bondi mass under the decay results predicted by the asymptotic expansion will be discussed. Naively the mass seems to be unbounded, but it will be shown first that the divergent terms can be replaced with a combination of the constraints and the Einstein field equations, and second that the Bondi mass loss formula is recovered within the framework. Both of the latter results hold in the presence of small constraint violations.