Covariant Self-force Regularization of a Particle Orbiting a Schwarzschild Black Hole

- Mode Decomposition Regularization -

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Covariant structure of the self-force of a particle in a general curved background has been made clear in the cases of scalar by Quinn, electromagnetic by DeWitt and Brehme, and gravitational charges by Mino, Sasaki and Tanaka, and Quinn and Wald. Namely, what we need is the part of the self-field that is non-vanishing off and within the past light-cone of particle's location, the so-called tail. The radiation reaction force in the absence of external fields is entirely contained in the tail. But these formulation are abstract, so when we apply to black hole-particle systems, there are many problems to be overcome in order to derive a concrete reaction force. These problems are roughly divided into two parts. They are the problem of regularizing the divergent self-force, i.e., "subtraction problem" and the problem of the singularity in gauge transformation, i.e., "gauge problem".

In this talk, we discussed a new approach to the subtraction problem. We have introduced the 'mode decomposition regularization' which utilizes the spherical-harmonic decomposition, and have derived the direct part of the self-force, which turns out to be independent of the spin s of the field under consideration. The harmonic decomposition of this direct part has been carried out, and the regularization counter terms for the self-force have been derived for a general geodesic orbit. We have found our result agrees completely with the result obtained by Barack and Ori in their mode-sum regularization scheme (MSRS).

Ref.) Y. Mino, H. Nakano and M. Sasaki, gr-qc/0111074 (2001).