Summary of past research

I have been studying the dynamics of and the gravitational waves from compact binaries, based on black hole perturbation theory. In this theory, a binary system is reduced to a point particle orbiting a black hole. The gravitational field and the motion of the particle are treated perturbatively. To predict the accurate waveform of the gravitational waves from the system, it is necessary to derive the "self-force" on the particle. Below I list my major studies on the self-force problem.

Adiabatic evolution of orbital parameters in Kerr geometry

The dissipation by gravitational radiation is the dominant effect on the secular orbital evolution of a particle moving around a black hole. In Kerr geometry, this effect can be described by the avaraged time variations of three orbital parameters (energy, angular momentum, and Carter parameter). I and my collaborators developed a simple method of calculating these variations from the fluxes of the gravitational waves at infinity and the horizon, under the adiabatic approximation [List of publications:7, 8]. In the work with Dr Fujita [28], we derived the 4th post-Newtonian formulas of the variations by using the method.

Our original method is not applicable to resonant orbits in Kerr geometry. In our recent work [35], we extended our method to resonant orbits, based on the Hamiltonian formulation of the self-forced motion.

Numerical calculation of the self-force in Schwarzschild geometry

The self-force correction to a orbit also contains the conservative effect, which cannot be described by the averaged time variations of the orbital parameters under the adiabatic approximation. The direct calculation of the self-force from the metric perturbation is necessary to evaluate the conservative effect. In my past works with Prof Leor Barack [10, 17], we formulated a way to compute the gravitational self-force on a particle orbiting a Schwarzschild black hole. We developed a numerical code based on our formulation, and succeeded in computing the self force and the corrections to orbital elements [15, 16, 19].

Synergy of the self-force calculation with other approaches

The results of the self-force calculation can be compared with the other approaches (post-Newtonian approximation, numerical relativity, effective-one-body model) through some gauge-invariant quantities related to the orbital dynamics. In our recent work [20], I and my collaborators compared the predictions of the periastron advance in Schwarzschild geometry, evaluated by the self-force and the different approches to check their consistency. We also demonstrated that the results of the self-force calculation give access to undetermined, higher-order post-Newtonian terms and the effective-one-body parameters [18, 23].

In addition to the studies mentioned above, I have worked on several topics related to gravitational wave physics, *e.g.* ringdown gravitational waves from compact binary coalescence [30, 33], data analysis with a network of ground-based detectors [9, 11], gravitational radiation from gamma-ray burst jets [5]. I also studied quantum fluctuations in brane world inflation scenario [1], cosmic censorship conjecture in orvercharging black hole [21].
