Summary of past research

I have been studying the dynamics of and the gravitational waves (GWs) 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 (BH). The gravitational field and the motion of the particle are treated perturbatively. To predict the accurate waveform of the GWs 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.

<u>Adiabatic evolution of orbital parameters in Kerr geometry</u>

The dissipation by gravitational radiation is the dominant effect on the secular orbital evolution of a particle moving around a BH. In Kerr geometry, this effect can be described by the averaged 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 GWs 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.

<u>Numerical calculation of the self-force in Schwarzschild geometry</u>

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 BH. 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]. This allows us to compare the self-force calculation with the post-Newtonian method and numerical relativity [20]. In addition, we proposed methods of predicting the unknown post-Newtonian coefficients and of calibrating the potentials in effective-one-body models [18, 23, 37].

In addition to the self-force problem, recently, I work on ringdown GWs from compact binary coalescence.

<u>Study on ringdown gravitational waves from compact binary mergers</u>

A compact object binary observed by LIGO/Virgo is expected to form a single BH as a result of the coalescence. The formed BH is distorted in its shape and radiate damped GWs, so-called ringdown GWs, in which the information on the BH is encoded.

So far, we investigated the relation between ringdown GWs and the effective potential in the perturbation equation [30], a method of testing the general relativity by using ringdown GWs [39], the importance of the overtones to ringdown GWs [43]. In addition, we studied on GW echoes induced by exotic compact objects [33, 36, 38].
