Taiga Miyachi

Graduate School of Science, Kobe University

Future Research Plan

Based on my research history, I plan to develop my research in the following directions:

1. Physical Implications of the Topology of Stokes Curves

In the analysis of Schwarzschild black holes, previous studies reproduced known results under the assumption of highly damped QNMs. However, exact WKB analysis can also derive QNM conditions for low-damped QNMs. In this case, the topology of the Stokes curves corresponding to low-damped modes exhibits non-trivial changes, offering potential new physical insights into black holes. The primary challenge in this analysis is the accurate calculation of phase integrals, which requires performing contour integrals on Riemann surfaces of genus one or higher. Developing methods for analytically or numerically evaluating phase integrals will enable deeper exploration of the physical significance of the topology of Stokes curves.

2. Applications to Beyond General Relativity

Exact WKB analysis can be applied to theories of gravity beyond general relativity. One of its main advantages is that it does not rely on the knowledge of special functions during analytic continuation. Thus, it is well-suited for analyzing gravitational theories with complex singular structures. Recently, research on QNMs in gravity theories beyond general relativity has become more active, and exact WKB analysis serves as a powerful tool for systematically analyzing these QNMs. In particular, applying this method to quantum-corrected black holes motivated by quantum gravity could contribute to advancements in quantum gravity research.

3. Study of Excitation Factors and Greybody Factors

Exact WKB analysis can also be applied to calculate black hole reflection and transmission coefficients, which are directly related to excitation factors and greybody factors. Excitation factors represent the initial gravitational wave amplitudes of each QNM, and numerical relativity studies have indicated that excitation factors for higher QNMs are significant. This aspect has recently gained attention, and exact WKB analysis is expected to elucidate its physical and mathematical background. Specifically, the connection to the topology of Stokes curves mentioned in Research Plan 1 could be crucial.

On the other hand, greybody factors appear as coefficients of black hole scattering processes and are discussed in the context of testing gravitational theories or holography as alternatives to QNMs. Using exact WKB analysis, greybody factors can be calculated even in parameter regions where conventional WKB approximations fail. Additionally, by extending these calculations to gravity theories beyond general relativity, we aim to gain new insights into these theories.

The research plans are envisioned to progress in the order $1 \to 2 \to 3$. However, in extreme cases such as highly damped QNMs, where approximate calculations of phase integrals work well, it may be possible to address Research Plans 2 and 3 earlier.