

## The 21 Century COE Project

Exploring New Science by Bridging Particle-Matter Hierarchy

### Short-term Foreign Researchers

### Research Report

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Host Researcher in Tohoku University: Yukinari Sumino

Your Stay Period in Japan: From 2004 March 1 to 2004 March 19

Title of Research in Japan:

Computations of higher-order corrections to  
observables of heavy quarkonium states



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Please write a research report of one or more pages and submit it with this cover to your host researcher till the end of this March.

## Research Report

Throughout my stay at Tohoku University, elementary particle theory group, I gave a lecture course on “potential-NRQCD”. This is an effective field theory which describes the heavy quarkonium system; it is used for contemporary perturbative computations of physical observables of heavy quarkonium systems. In the lecture course, I covered several topics: (1) The construction of potential-NRQCD, the matching procedure from QCD to NRQCD and then from NRQCD to potential-NRQCD, (2) Miscellaneous exercises: computations of ultrasoft loops, spectrum of positronium up to  $\mathcal{O}(\alpha^5 m)$ , etc. (3) Renormalization group equations and resummation of soft logs, ultrasoft logs and potential logs, (4) Renormalons, and (5) Static potential-NRQCD and gluelumps.

I also gave a seminar, with an introductory review to the potential-NRQCD formalism and application to the computations of heavy quarkonium spectrum, decay widths and the static QCD potential.

During the later part of my visit, I had extensive discussion with the members of the institute, mainly with Dr. Y. Sumino, on heavy quarkonium physics and related subjects. Besides what I have covered in my lecture course, we discussed e.g. the shift of power counting of the renormalons contained in the ultrasoft correction to the static potential, and how to treat renormalons in a natural manner in dimensional regularization. For the latter problem, we came up with some ideas through discussion, and we hope to study consequences further in the future.

I also learned technical details of the study on the “Coulomb+linear” potential on which Dr. Sumino has been working recently. Since I was able to ask questions directly, which would have been difficult to ask otherwise, it was helpful to develop my understanding of the study.

I also visited Kyoto Yukawa Institute during my stay and had enlightening discussion with Prof. Onogi, in particular on some applications of potential-NRQCD to lattice QCD.

In summary, my visit to Tohoku University was very fruitful. I could exchange information on the recent progress of the physics in heavy quarkonium states and QCD potential, and new insights into possible directions of the future research were gained.