Activity Report of the NAOJ Visiting Scholar Program

Host Project/Division: Division of Theoretical Astronomy Name of Host Scientist: Toshitaka Kajino

Name of Visiting Scholar: Cemsinan Deliduman

Title: Visiting Professor

Period: from 2017/04/01 to 2017/07/31

I. Report from the visiting scholar

[i] Achievement during the period of stay (in comparison with the initial plan)

(Collaborative Research)

1) Soft or super-soft EoS for neutron stars
General relativity predicts that neutron stars with soft or super-soft EoS cannot have masses as large as M ~ 2.5 M$\odot$, which is expected to be the upper limit on neutron star masses according to observations and statistical considerations. There are, however, many indications that the nuclear symmetry energies at supra-saturation densities in various astrophysical settings have to be soft or even super-soft. Since general relativity together with soft or super-soft EoS does not agree with the observations, one expects to resolve this paradox by modifying the gravity theory. During my stay at NAOJ we worked extensively on one specific theory, so called the Weyl theory of gravity. We simplified field equations and obtained some important results.

2) Soft or super-soft EoS for proto-neutron stars in core collapse supernovae
Extremely soft EoS induces strongest shocks, resulting in most energetic explosions. In such manners supra-saturation EoS is important not only for supernova dynamics, but also for the nature of neutrino signals. Again since general relativity together with soft or super-soft EoS does not agree to observations, one can try to resolve this problem by modifying the gravity theory. There are parallel problems in the dynamics of type Ia supernovae and physics of white dwarfs. We studied the significance of soft or super-soft EoS for proto-neutron stars in core collapse supernovae in the framework of specific modified gravity theory mentioned above. This study is related to the core collapse supernova dynamics, r-process nucleosynthesis of heavy elements in supernovae, nature of neutrino signal form supernovae, as well as white dwarf physics and the type Ia supernovae dynamics

3) Gravitational waves from neutron star merger
LIGO and VIRGO collaborations have observed gravitational waves from several black hole mergers and also from a neutron star merger. The neutron star merger provided many interesting facts about EoS of the merging neutron stars. Although gravitational wave observations support the Einstein's view of gravity as the space-time phenomena, they are much deeper to allow modifications of general relativity as well. We started an investigation of compatibility between expected EoS's for the merging neutron stars and the modified gravity theories. Other than that observed signals from black hole mergers allow some range of values for the post-Newtonian parameters, that is mass and angular momentum, of merging black holes. This means that it is possible that merging black holes with slightly different values of mass and angular momentum, but with very different horizon geometry than general relativistic expectations, would still give rise to the observed gravitational wave shape. Our studies in these

4) Big-bang nucleosynthesis in alternative cosmology
Abundance of light elements (Hydrogen, Deuterium, Helium-3 and Helium-4) are well predicted by the standard model of cosmology. However there is unexplained discrepancy with the observed abundance of Lithium-7 nuclei and the theory. Alternative cosmological models can be constructed with the aim to resolve this so called Lithium-7 problem. One way of attacking this problem is again via modification of gravity. On cosmological scales the theory of gravity has utmost importance and modification of gravity changes cosmological evolution significantly. I analyzed field equations of Weyl gravity on a cosmological setting with NAOJ experts on Big-bang nucleosynthesis.

(Education)

1) I gave a series of 7 lectures on "Particle Cosmology and Modern Gravity" in the Astronomy Department of University of Tokyo. Several graduate students from NAOJ, University of Tokyo and Nagoya University attended at those lectures. After the lectures we had extensive discussions on the current status of cosmology.

(Others)

1) DTA Colloquium Talk: "Astrophysics with Weyl Gravity" on June 14th 2017.

2) Public Talk to Engineering Students at Istanbul: "History of Cosmology; From my International Research in Turkey, US, and Japan" on November 30th 2017.

[ii] Any comments on this program

The visiting professor program of NAOJ helped me to discuss and work together with world class scientists here at NAOJ. I collaborated and had extensive discussions of physics with Prof. Kajino and Prof. Takiwaki, as well as many graduate students in the COSNAP group. I had very valuable discussions and collaborated also with Prof. Grant Mathews of Notre Dame University, Prof. A. Baha Balantekin of University of Wisconsin, Prof. Michael Famiano of Western Michigan University, Prof. Myung-Ki Cheoun of Soongsil University and Prof. Motohiko Kusakabe of Beihang University, who were also visiting during my stay at NAOJ. The research environment of NAOJ is very stimulating and allows full potential of scientists to flourish. Thus the NAOJ visiting professorship program establishes a leadership in science under which international collaborations produce much fruitful results.

[iii] List of publications and presentations by the visiting scholar in collaboration with NAOJ staff or graduate students

(Publications)

1) Cemsinan Deliduman, Oguzhan Kasikci and Baris Yapiskan (Mimar Sinan Fine Arts University),
Flat Galactic Rotation Curves from Geometry in Weyl Gravity;
under review at Modern Physics Letters A.

2) Onur Pusuluk (Istanbul Technical Univ.), Tristan Farrow (University of Oxford), Cemsinan Deliduman (Mimar Sinan F.A. Univ.), Keith Burnett (University of Sheffield), Vlatko Vedral (University of Oxford),
Proton tunneling in hydrogen bonds and its implications in an induced-fit model of enzyme catalysis;
under review at Royal Society Proceedings A.

3) Onur Pusuluk (Istanbul Technical Univ.), Tristan Farrow (University of Oxford), Cemsinan Deliduman (Mimar Sinan F.A. Univ.), Keith Burnett (University of Sheffield), Vlatko Vedral (University of Oxford),
Emergence of correlated proton tunneling in water ice;
under review at Royal Society Proceedings A.

(Presentations)

4) Intensive Lectures at University of Tokyo: "Particle Cosmology and Modern Gravity"
on July 19th-21st 2017.

5) Seminar at Waseda University: "Cosmology with Weyl Gravity" on July 13th 2017.

6) Seminar at University of Tokyo: "Astrophysics with Weyl Gravity" on July 18th 2017.

II. 以下の項目について、受入教員が記入してください。

Report from the host scientist

[iv] 本制度に対する意見、要望など

Any comments on this program

This was a fruitful time for research and discussions with Prof. Cemsinan Deliduman and many other scholars. We completed several ongoing projects and started new ones during his stay at NAOJ Mitaka. The opportunity for our graduate students and post docs to interact with him was inspiring for their development as researchers. I sincerely believe that this provides substantial enrichment for all scientists.