STEPS Students Report

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During my stay, I studied the general relativity and gravitational waves. To understand some astrophysical phenomena or cosmology, it is necessary to have knowledge of general relativity. My graduation research will be about an astrophysical phenomenon, which is related to general field. Therefore, I wanted to study general relativity in Russia, who many great physicists were born to prepare for my graduation research.

Prof. Denisov's lecture started from the Riemannian geometry or the tensor analysis to understand the general relativity more smoothly. In the general relativity, there are many indexes, which represent the dimension, one time dimension and 3 spacial dimensions, and we sum each indexes up. The number of equations often amount to 64 or 160. However, Thanks to prepared lessons and tough homework from Prof. Denisov, now I will never afraid of very complicated equations. I could understand how to write equations in curved space-time.

After that, he illustrated the case of lower dimensions. The Riemannian geometry is so abstract that it is difficult to imagine what equations means. Therefore, the lower dimension case was very useful to grasp the geometrical meanings.

After I mastered the basis of the Riemannian geometry, the tensor analysis, and its meaning, I turned to the physical meaning of the tensors. In the General Relativity, gravity is represented as the curvature of space-time. On this space-time, matters, which represented as energy-momentum tensor, moves with satisfying the Einstein equation. To lead to this elegant equation, Prof. Denisov started from a principle, the Euler-Lagrange equation. His explanation was straight, and I studied mathematical prerequisite just before, so I appreciated the beauty of the equation. I wondered that why the nature is so ordered mathematically.

Regarding the Euler-Lagrange equation, an associate professor Vladimir, who studies the non-linear electro-dynamics, explained that there is problem in classical electro-dynamics and how to manage it by modifying the Euler-Lagrange equation. It was fantastic.

Finally, using the general relativity, we proved that the perihelion of planets, which does not move in the Newtonian mechanics, moves, and that the path of light that passes through the side of the sun is bend. These phenomena were actually used as the proof of the general relativity 100 years ago.

In my short stay, I only could understand the basis of the general relativity, and I could not accomplish the first purpose of understanding the primordial gravitational waves, which is thought to happen in the inflation duration. However, thanks to Prof. Denisov and Prof. Vladimir, now I am able to understand the textbooks about the cosmology. So, it is my homework in Japan.