

The 21 Century COE Project  
Exploring New Science by Bridging Particle-Matter Hierarchy

Short-term Foreign Researchers

**Research Report**

Name: Prof. S. G. Tikhodeev

Affiliation: *General Physics Institute RAS, Vavilova 38, Moscow 119991, Russia*

Host Researcher in Tohoku University: Teruya Ishihara

Your Stay Period in Japan: From Feb.2 to Feb.6, 2004

Title of Research in Japan:

Optical properties of metallic photonic crystals

---- Notes ----

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.

Prof. S. G. Tikhodeev

*General Physics Institute RAS, Vavilova 38, Moscow 119991, Russia. e-mail [tikh@gpi.ru](mailto:tikh@gpi.ru)*

**Report on the research work during my visit to Department of Physics, Tohoku University, Sendai, 2-6 February 2004**

During my visit to Department of Physics, Tohoku University, Sendai, I gave a seminar talk "Waveguide-plasmon polaritons in photonic crystal slabs with metal nanowires", in which I discussed the recent experimental and theoretical findings concerning the metallic-dielectric photonic crystal slabs. Additionally, I enjoyed several very informative scientific discussions with professors of the Department of Physics, Tohoku University. With Prof. R. Saito we discussed the excitonic properties in carbon nanotubes. With Dr. N. Horiuchi and Prof. Y. Segawa we have discussed their novel experimental work on the Smith-Purcell effect from a photonic crystal slab made of dielectric spheres. I had a discussion with Prof. S. Iwai on ultrafast dynamics in the highly correlated compounds. There was also an interesting discussion with Prof. Sh. Suto, on the electron loss spectroscopy of plasmons in metal nanoparticles.

The most important part of my discussions were held with Prof. T. Ishihara. These discussions were focused mainly on the photo-voltaic effect in metallic photonic crystal slabs. The experimental work in this direction is developing by Prof. T. Ishihara groups in RIKEN, and also in Tohoku, with Dr. M. Iwanaga. The theoretical work on the explanation of this effect is now undertaken by Dr. N.A. Gippius and myself. We have discussed an important point, concerning the momentum transfer from the incoming photons to the photonic crystal slab, during the excitation of surface plasmon and diffraction. There is no clear theoretical understanding in this important point, and new investigations are needed. We have also discussed the theoretical problem of slow or even non-existent convergence of the Fourier-based methods for the calculations of the photovoltaic effect.

Another topic of our scientific discussions with Prof. T. Ishihara was the comparison between the FDTD- and scattering-matrix-based calculations of the optical response and electromagnetic near-field distributions in metallic photonic crystal slabs. The main concern in the S-matrix calculations is a slow convergence of the Fourier series. The main problem of the FDTD calculations is a difficulty in accounting for frequency dispersion of the metal dielectric function. We agreed that it is important to make a special comparison on a photonic crystal structure with a model Drude-type metal, with a single plasmon frequency.

Another topic which was discussed is the possible fundamental problems which can be addressed in the physics of photonic crystals. One of such problems might be the calculation and experimental investigation of the nonlocal response in photonic crystals.

Additionally, we have discussed our paper "~~Optical properties of photonic crystal slabs with asymmetrical unit-cell~~" by N. A. Gippius, S. G. Tikhodeev, and T. Ishihara, which was at the last stage of the preparation for submission to Phys. Rev. Lett. at that time, and the plans for future collaboration.

To conclude, my visit to Department of Physics, Tohoku University was very informative and I am very thankful to Prof. T. Ishihara for inviting me. I would like to mention specially a friendly atmosphere at Prof. T. Ishihara laboratory and in the Department of Physics, a high level of scientific discussions, which were of great importance for me. Also I enjoyed the environmental beauty of the Tohoku university location.

S. G. Tikhodeev

2 March 2004