SECTION DE PHYSIQUE

# COLLOQUE DE PHYSIQUE

24, QUAI ERNEST-ANSERMET, CH-1211 GENÈVE 4

# Colloque extraordinaire
# Leçon d'adieu

**Lundi 25 octobre 2021, 17h00**

Ecole de Physique, Grand Auditoire

## « Things about light and matter that we don't understand but would like to fathom »

Prof. Dirk Van der Marel
*Université de Genève*

Résumé

Light and matter can be conveniently combined and made to interact. This interaction is weak enough to allow light to travel more than 100 kilometers in a glass fiber without being absorbed and strong enough to discern a single atomic layer of graphene by eye. These two facts of light and matter can be completely understood from the laws of refraction formulated by August Fresnel almost 2 centuries ago, laws that continue to be widely used in the description of light-matter interactions. The need of a correction to the laws of Fresnel, even in the context of classical (i.e. pre-quantum) description, had been spotted by Sauter half a decade ago, and he and others have demonstrated theoretically and experimentally that this tiny correction allows to launch electron-plasma waves in a thin metal sheet with the help of a light source. However, before soon other methods for exciting plasmons took over. Sauter's work was soon forgotten yet progress on this front is dearly needed, especially and in particular in view of several spectacular experimental developments in near field optics and electron optics. To go beyond the phenomenology of Fresnel's laws and develop a microscopic understanding of materials, we have to appeal to the quantum theory of light, matter and light-matter interactions. We can predict a lot of properties of solids, under the approximation that the electrons in the solid don't interact with each other. However, the total lack of realism of that approximation makes predictions unreliable. To give an example: the color of a metal changes dramatically if and when it becomes superconducting. This color change happens in the infrared range and it is a manifestation of the Higgs mechanism. However for certain superconducting materials the color even changes for the visible spectrum. The reason why this happens at such high frequencies is not understood. However. it is believed that understanding this would provide a key to the mechanism of superconductivity in these materials. The subject of electron-electron correlations is highly theoretical, and at the same time it is experimentally totally under explored. Superconductivity and magnetism are the best-known manifestations of correlation of electrons. A dream is to follow experimentally the correlated motion of electrons and spins in real time and space, and thereby fathom superconductivity, magnetism and newly emerging phenomena. Such experiments with light, electrons, or combinations of these can in principle be developed. In this respect some beginnings have been made, and a great future lies ahead.

Prof. Dmitry Abanin

Genève, le 8 octobre 2021/nc

Secrétariat de la Section de Physique - N. Chaduiron – 022 - 379.63.83