IBS CINAP Seminar

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Characterizing two-dimensional (2D) materials by Raman spectroscopy

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The pioneering experiments with graphene in 2004 opened a new area of research in science, which is the study of two-dimensional (2D) crystals. The behavior of the electrons in these materials depends not only on the atomic and crystalline structure, but also on the number of layers and the stacking order between layers. For example, the electronic structure of bilayer graphene depends strongly of the twisting angle between the layers. Several new 2D systems have also been produced and studied, including an allotrope form of phosphorus, called black phosphorus, and the semiconducting transition metal dichalcogenides MX_2 (M = Mo, W and X = S, Se, Te). In this presentation, I will first discuss how Raman spectroscopy provides information about electrons, phonons and their interactions in 2D materials. I will present a Raman study on black phosphorus edges that show the appearance of edge phonons, and theoretical simulations confirm that they are originated by the atomic rearrangements at the crystalline terminations [1]. I will then present a multiple excitation Raman study in MoS_2, where we could evidence electron scattering processes by acoustic phonons between different valleys in the electronic structure [2]. I will present results in twisted bilayer samples and graphene on the top of h-BN and show the ability of Raman spectroscopy to probe and distinguish interlayer and intralayer electron-phonon interactions in graphene heterostructures [3]. Finally, I will present some preliminary results of polarized Raman spectroscopy in the anisotropic compound $ReSe_2$.

1. H. B. Ribeiro et al, Nature Comm. 7, 12191 (2016)
2. B. R. Carvalho et al. Nature Comm. 8, 14670 (2017)
3. G. S. N. Eliel et al. Nature Comm. 9, 1221 (2018)

Marcos A. Pimenta is since 1989 professor at the Department of Physics of Federal University of Minas Gerais (UFMG) in Belo Horizonte, Brazil, and in 1992 he created the Raman spectroscopy Laboratory at UFMG. In 1997, he started the research area of carbon nanomaterials (nanotubes and graphenes) at UFMG using, mainly, Raman spectroscopy. He published around 200 articles and his h-factor is 59. He has won national and international awards, including the Scopus-CAPES prize in 2008 for the visibility of his scientific works, the Somyia award in 2009, delivered by the IUMRS, for the collaborative works with US, México and Japan groups. In 2010, he received the command of the Brazilian Order of Scientific Merit, and was ellected as a full member of the Brazilian Academy of Sciences. He got the 2013 TWAS Prize in Physics and the 2014 Marcos Mares-Guia Prize (FAPEMIG) in Minas Gerais, Brazil. He is a member of the Brazilian Academy of Sciences and the Brazilian Physical Society. Currently, he is the director of the Brazilian Institute for Science and Technology (INCT) of Carbon Nanomaterials and the president of the Brazilian Physical Society (SBF).