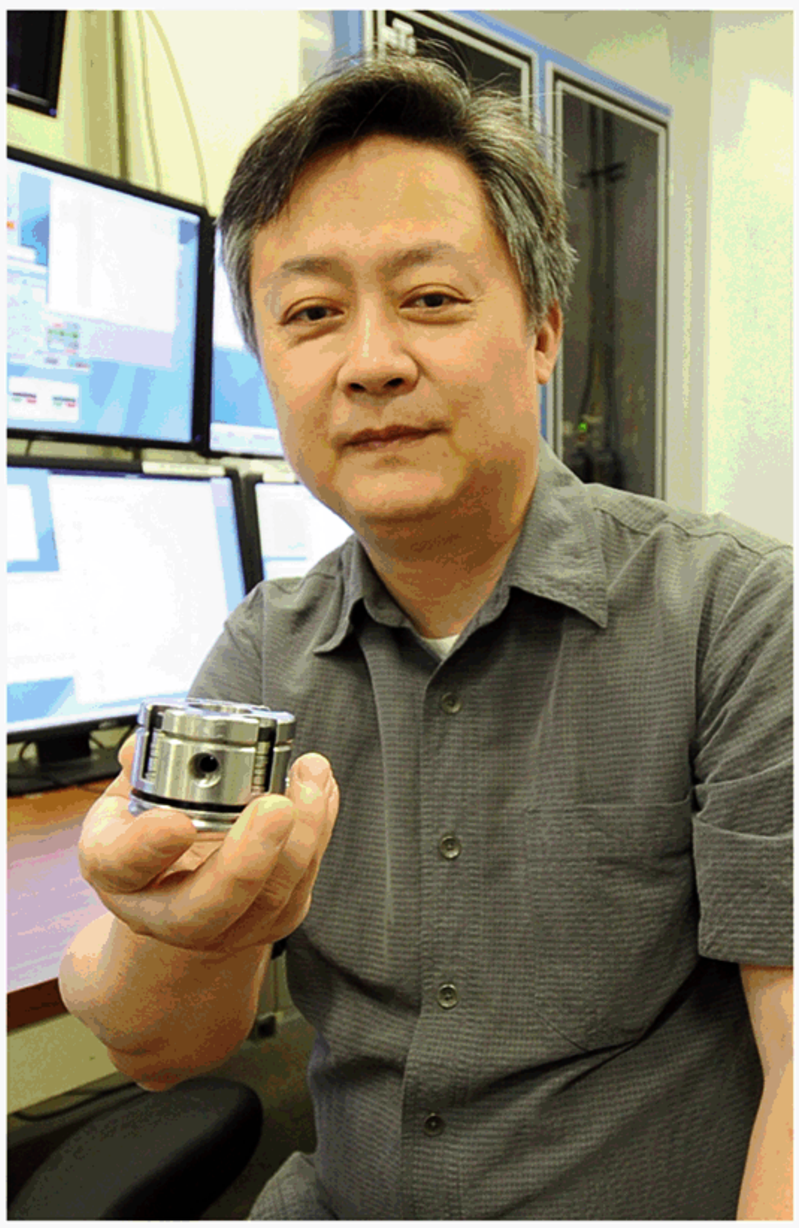
The Advanced Photon Source

RIXS and a DAC Lead to the Discovery of a Novel Confined Metal

Insulator-metal transitions (IMT), where a material changes from an insulator to a metal with substantially enhanced electrical conductivity, represent an important topic in contemporary condensed matter physics and an opening to a new field for synthesizing functional materials. Recent experiments at the Advanced Photon Source (APS) at Argonne found that strontium iridium oxide, $Sr_3Ir_2O_7$, undergoes just such an IMT and becomes a confined metal at high pressure, showing metallicity in the crystal *ab*-plane but insulating along the *c*-axis. Such unusual behavior resembles the strange metallic phase encountered in cuprate high-temperature superconductors.

$Sr_3Ir_2O_7$ is a compound belonging to the Ruddlesden-Popper perovskite iridates $Sr_{n+1}IrnO_{3n+1}$ (where n is the number of $SrIrO_3$ perovskite layers between extra SrO layers), and it is insulating at ambient condition. The relatively low electrical resistivity and small charge gap of $Sr_3Ir_2O_7$ suggest that the material can undergo a potential IMT upon external perturbation, such as carrier doping, magnetic field, or external pressure.

In a recent study, the research team performed electric resistance and resonant inelastic x-ray scattering (RIXS) measurements at the X-ray Science Division 27-ID-B and 30-ID-B,C x-ray beamlines at the APS on $Sr_3Ir_2O_7$ for the first time under high pressure, employing diamond anvil cell (DAC) techniques. The resistance measurements indicated an IMT occurring at around 59 GPa, and the resulting high-pressure phase exhibited a novel confinement phenomenon: metallic behavior within the *ab*-plane, but an insulating one along the *c*-axis.



Study lead author Yang Ding (HPSTAR, Argonne, and the Carnegie Institution of Washington) in the Sector 27 beamline control room, holding a DAC.

The discovery of a novel high-pressure metallic phase with intriguing confinement characteristics similar to those found in overdoped cuprate superconductors suggests that superconductivity could potentially be found in doped $Sr_3Ir_2O_7$ under high pressure.

See: Yang Ding*, Liuxiang Yang, Cheng-Chien Chen, Heung-Sik Kim, Myung Joon Han, Wei Luo, Zhenxing Feng, Mary Upton, Diego Casa, Jungho Kim, Thomas Gog, Zhidan Zeng, Gang Cao, Ho-kwang Mao, and Michel van Veenendaal, "Pressure-Induced Confined Metal from the Mott Insulator $Sr_3Ir_2O_7$," Phys. Rev. Lett. **116**, 216402 (2016). DOI: 10.1103/PhysRevLett.116.216402

Correspondence:
*yang.ding@hpstar.ac.cn

C.C.C. is supported by the Aneesur Rahman Postdoctoral Fellowship at Argonne. H.-S.K. and M.J.H. were supported by the Basic Science Research Program through NRF (Grant No. 2014R1A1A2057202) and by Samsung Advanced Institute of Technology. G.C. acknowledges National Science Foundation support via Grant No. DMR1265162. H.-k. M. acknowledges the support of the U.S. Department of Energy (DOE)-Basic Energy Sciences under Award No. DE-FG02-99ER45775 and NSFC Grant No. U1530402. M.v. V. is supported by the U.S. DOE under Award No. DE-FG02-03ER46097, and by the Institute for Nanoscience, Engineering, and Technology at Northern Illinois University.

This research used resources of the Advanced Photon Source, a U.S. DOE Office of Science User Facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.

Advanced Photon Source
Bldg. 401/Rm A4115
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439 USA
www.aps.anl.gov
apsinfo@aps.anl.gov

Argonne NATIONAL LABORATORY
www.anl.gov

U.S. DEPARTMENT OF ENERGY
Office of Science