Photonic spin-Hall effect in single catenary nanoholes

The photonic spin-Hall effect is an important but intrinsically weak effect at the nanoscale. Xiangang Luo and co-workers from the Institute of Optics and Electronics, Chinese Academy of Sciences, found that a single catenary-shaped hole can generate a near-perfect spin-Hall effect (see Fig. 1). As one of the smallest photonic devices reported so far, the curvature of the catenary acts as an effective magnetic field and makes circularly polarized light bend in opposite directions in a broadband spectrum. It opens a door to the utilization of continuous nanostructures as miniaturized functional optical devices.

[Lo X et al. Light-Sci Appl 2017; 6: e16276.]

Insight-HXMT contributes to understanding the binary-neutron-star merger gravitational-wave event

After the 2016 announcement of the discovery of gravitational waves, the most significant breakthrough in astronomy is the discovery and multi-messenger observation of the gravitational-wave event GW170817 from the merger of two neutron stars. Insight-HXMT, China’s first X-ray astronomy satellite, launched on 15 June 2017, observed the entire event, as reported by TiPei Li (Institute of High Energy Physics, CAS, Tsinghua University, and University of Chinese Academy of Sciences), Shuang-Nan Zhang (Institute of High Energy Physics, CAS, and University of Chinese Academy of Sciences) and co-workers. The short gamma-ray burst detected by Fermi/GBM and Integral/ACS was unexpectedly weak and soft and thus was not detected but tightly constrained by Insight-HXMT between 200 keV and 5 MeV, which can help in the understanding of the physical process of the binary-neutron-star merger.

[Li TP et al. (The Insight-HXMT team) Sci China Phys Mech Astron 2018; 61: 031011.]

Air-stable diradical dication with a large singlet–triplet energy gap

Triplet ground state (S = 1) diradicals with large singlet–triplet energy gap over the thermal energy at room temperature (ΔE_{ST} >> 300 K) have attracted great interest, as they could be used as building blocks in the design of magnetic materials and biomedical agents. However, the number of such species is limited. Recently, Wenqing Wang and Xinping Wang from Nanjing University reported an air-stable dication of tert-butyl-substituted tetraazacyclophane, which shows a discrete diradical geometry with strongly ferromagnetic interaction (2J = 535 K), demonstrating that a class of arylamine-based diradical dications with strong ferromagnetic interaction will be accessible.

[Wang W et al. Sci China Chem 2018; 61: 300–5.]

RNA epigenetic modification is required for regulatory T-cell immune-suppression

RNA m^6A modification was recently found to be essential in mRNA metabolism and involved in the functions of all kind of cells in vitro, but its in vivo function in effector T cells is unknown. Hua-Bing Li of Shanghai JiaoTong University, Richard Flavell of Yale University and co-workers specifically deleted the RNA m^6A marker ‘writer’ gene Mettl3, which is involved in the resolution of inflammation and immunosuppression in tumor
microenvironments, in regulatory T cells only. Deletion of the writer gene and consequent loss of the m6A marker led to severe whole-body autoimmune inflammation and eventually death of the animals. Mechanistic studies revealed that m6A targeted specific essential signaling pathways of the regulatory T cells, thus controlling their suppressive functions. This study points to the possibility that specific depletion of m6A in tumor-infiltrated regulatory T cells could be harnessed in combination with other forms of immunotherapy to combat tumors.

[Tong J et al. Cell Res 2018; 28: 253–6.]

PLANT & ANIMAL SCIENCE

Circadian evening complex represses leaf senescence

Circadian clock and senescence have been shown to tightly intertwine with each other in numerous eukaryotes, but the regulation of the circadian oscillator on triggering leaf senescence in higher plants remains largely unknown. Recently, Lei Wang’s group at the Institute of Botany, Chinese Academy of Sciences, discovered that evening complex (EC), a core component of the plant circadian oscillator, negatively regulates leaf senescence, by transcriptionally repressing MYC2, which encodes an essential component of the jasmonic acid (JA) signaling pathway to trigger leaf senescence in Arabidopsis (see Fig. 2). Their findings not only revealed a key underlying mechanism for circadian gated JA signaling in triggering leaf senescence, but also closed the knowledge gap of a long-sought-after transcriptional regulation between the circadian core oscillator and JA signaling.

[Zhang et al. Mol Plant 2018; 11: 326–37.]

How pigs fight against the cold

Brown adipose tissue (BAT) and uncoupling protein 1 (UCP1) are crucially important for small mammals to generate heat in cold environments to maintain body temperature. However, pigs lost UCP1 about 20 million years ago and do not have BAT. Jianguo Zhao from the Institute of Zoology, CAS, and his colleagues reported that cold-resistant Tibetan and Min pigs fight the cold by relying on the formation of beige adipocytes and increased expression of UCP3. Their observations challenge the orthodoxy based on studies of mice that only UCP1 may act as a significant source of thermogenic heat and provide a new target for genetic engineering in pig breeding.

[Lin J et al. J Mol Cell Biol 2017; 9: 364–75.]

NEUROSCIENCE

Alzheimer’s-disease-related enzymes (α- and β-secretases) physically and functionally interact with each other

α- and β-secretases compete for amyloid precursor protein ectodomain cleavage, which is vital to Aβ pathology in Alzheimer’s disease. However, whether they function separately or together remains unknown. Gang Pei’s group from the Shanghai Institute of Biochemistry and Cell Biology found that ADAM10 and BACE1, the major α- and β-secretases in the brain, co-localize and physically interact in neurons. ADAM10 enhances BACE1-mediated cleavage of a neuronal substrate (CHL1) and this regulation is dependent on their physical interaction. The study indicates that the interaction between the two critical enzymes regulates proteolysis of some sharing substrates and thus may delicately coordinate their function.

[Wang X et al. J Mol Cell Biol 2018; doi: 10.1093/jmcb/mjy001.]

Topological quantum catalyst using nodal-line semimetals

Traditionally, design of catalytic materials requires highly active sites through effective control of nanoengineering, heterostructures, defects and edges or boundary states. Xing-Qiu Chen at the Shenyang National Laboratory for Materials Science, Institute of Metal Research, CAS, and co-workers have proposed a new concept of topological quantum catalyst utilizing Dirac nodal-line semimetals because of the combined advantages of robust drumhead-like topologically protected surface states, high carrier density and good mobility (see Fig. 3). Moreover, the TiSi family has been suggested as a potential candidate for this functionality, catalyzing electrochemical hydrogen production from water.

[Li JX et al. Sci China Mater 2018; 61: 23–9.]

Metal–organic frameworks as new materials for optical ceramics

Conventional ceramics are solid materials consisting of inorganic, nonmetallic micro/nanocrystals sintered at high
temperatures while optical ceramics are transparent for the elimination of birefringence, impurities, defects etc. Jie-Peng Zhang at Sun Yat-Sen University and co-workers demonstrated metal–organic frameworks (MOFs) as a new type of material for optical ceramics. At low solvent evaporation rate, MOF nanocrystals can fuse together and form coherent masses with micrometer sizes, high optical transparency as well as an outstanding amplified spontaneous emission property. This facile sample-processing method can broaden the applications of MOFs in many fields. [Ye J-W et al. Sci China Mater 2018; 61: 424–8.]

**MATERIALS SCIENCE**

**Effective exposure of active sites for energy conversion and storage**

The introduction of nitrogen heteroatoms into carbon materials renders high reactivities in energy conversion and storage. However, most heteroatoms are doped into the bulk phase of carbon, which significantly reduces the contact of feedstocks with the active dopants in a conductive scaffold. Qiang Zhang at Tsinghua University and co-workers proposed the effective exposure of nitrogen active sites on surface graphene skin in a carbon/carbon composite. More N heteroatoms are able to come into contact with the oxygen feedstocks in oxygen reduction reactions or serve as polysulfide anchoring sites in lithium–sulfur batteries. [Shi JL et al. J Energy Chem 2018; 27: 167–75.]

**INFORMATION SCIENCE**

An efficient approach to enhance human–robot interactions with shared control

Jie Chen at the Beijing Institute of Technology and co-workers proposed an optimization-based shared-control framework (see Fig. 4), where human intention is predicted as an additional cost of model predictive control (MPC) and a compromise between human intention and robots’ original objectives is properly made by optimizing the blended cost. The advantages of the proposed shared-control framework are that both human and robot objectives can be achieved in the MPC system that is input-to-state stable; meanwhile, the human intervention burden can be greatly reduced. These results provide a general way to promote the safety and efficiency of human–robot systems. [Fang H et al. Sci China Inf Sci 2018; 61: 014201.]