CHINA SCIENCE AND TECHNOLOGY NEWSLETTER

Department of International Cooperation
Ministry of Science and Technology(MOST), P.R.China

No.12
June 30 2016

China's achievements of scientific and technological innovation in 12th Five Years

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China's achievements of scientific and technological innovation in 12th Five Years

Basic Research and Facilities

China's basic research saw rapid development in the 12th Five years (2011-2015), with optimized academic structures, mushrooming of leading research teams, improvement of R&D capabilities and facilities, and growing of international influence and overall science & technology strength.

Chinese scientists first discovered iron-based superconductors with transition temperature higher than 40K, and found a series of iron-based superconductors with transition temperature higher than 50K. Chinese researchers first observed the quantum anomalous Hall effect in an experiment, discovered zero-mass chiral electron – Weyl fermions, analyzed the three-dimensional structure of schizosaccharomyces pombe spliceosome, human γ-secretase complex associated with Alzheimer's disease, the largest known receptor of calcium ion and human glucose transporter.

Construction of large-scale scientific facilities has made great progress: the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) was built in Qiannan, Guizhou; Dark Matter Particle Explorer Satellite Wukong was sent into space; the world's deepest underground laboratory with the smallest cosmic ray flux and the most sensitive results was put into service for the study of dark matter.

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More and more Chinese scientists stepped onto the international stage. Professor Tu Youyou became China's first scientist that received the Nobel Prize. Professor Wang Yifang was honored with the 2016 Breakthrough Prize in Fundamental Physics. Quantum teleportation of multiple degrees of freedom of a single photon, discovered by a research team led by Professor Pan Jianwei, won the Physics World 2015 Breakthrough of the Year.

Fundamental research is playing a greater role in satisfying China's needs. Substantial progress has been made in molecular breeding of rice, analysis of persistent organic pollutants and immunoregulation. These accomplishments have laid important theoretic foundation for addressing agricultural, environmental and health challenges. Remarkable breakthroughs in nano-particle confined catalysis and plasmon-based optical control have provided theoretic basis for the cultivation of emerging industries and the development of disruptive technologies.

China's fundamental research expenditure was RMB 67.06 billion in 2015, up by 34.4% from 2012, translating into an average annual growth of 10.4% in the three-year period. The full-time equivalent of fundamental research staff increased from 131,300 person years in 2006 to 223,200 person years in 2013. For many years, China has been the world's second largest producer of international science papers, with total citations rising up to the fourth in the world and to the second in seven subjects like agriculture, chemistry and material science. These numbers reflect the great contribution of the Chinese scientists to knowledge innovation, economic growth and social progress.

Between 2011 and 2015, China built 162 state key laboratories, bringing the total number to 481 by the end of 2015. The country also set up seven pilot national laboratories and 32 major national science and technology infrastructure projects.

In the five-year period, China earmarked RMB 16 billion to state key laboratories, providing steady financial support to the national bases of fundamental research. The state key laboratories and pilot national laboratories, based on universities and research institutes, have covered more than 80% of the subjects on basic research.

In the five years, the National Science and Technology Infrastructure Platforms have provided support to over 78,000 research programs under the National Major Science and Technology Projects as well as other science & technology initiatives and served 3.5 million users. These platforms helped produce 52,582 research papers, 7,748 granted patents, 2,839 standards as well as 1,402 academic monographs, playing a supportive role for China's science, technology and innovation.

So far, the portal website for sharing of China's science and technology resources (www.escience.gov.cn), has integrated information and resources from 952 universities and research institutes, and 569 key laboratories, engineering centers, large instrument centers and field stations, providing 5.11 million pieces of metadata for information navigation and retrieval.

Through the adoption of innovative technologies like big data analysis, intelligent extraction of huge amounts of heterogeneous soil, mapping and representation, China's soil scientists drew a highly accurate digital soil map with a scale of 1:50,000. The map is by far the most complete and precise account of China's soil resources and can provide scientific data of soil resources at different places across the country.

There have been intense international competitions to set up Global Stratotype Section and Point (GSSP), commonly referred to as "Golden Spike", because the number of GSSPs awarded to a country is a general indicator of its comprehensive strength and research capabilities in the field of stratigraphic geology. China has been awarded 10 GSSPs, more than any other country on the planet.

China has set up 105 national field stations for observations of ecological environment, special environment and atmospheric background, material corrosion and physical geography. A field observatory system has taken preliminary shape.

(Source: Science and Technology Daily, May 31, 2016)

Major National Projects on Science and Technology

In the five-year period, with the institutional support of nationwide resource mobilization, Major National Projects on Science and Technology enabled Chinese scientists to overcome major challenges; improve core competitiveness; develop high-end equipment in response to urgent strategic needs and major products to the benefit of people's livelihood. The projects also built a group of internationally competitive enterprises, developed high-standard innovation platforms and industrialization hubs, trained domestic and overseas professionals, raised China's innovation capacity and facilitated China's efforts to develop strategically important core technologies, nurture emerging industries and new sources of economic growth.

High-end chips for national information security

China mastered key technologies essential for core electronic components, operating systems and high-end generic chips like CPUs for super computers, Internet servers and SoCs. The country succeeded in promoting R&D of proprietary software and hardware systems.

IC manufacturing technology: collective breakthroughs in advanced equipment manufacturing

China made collective breakthroughs in manufacturing advanced equipment like etching machines, PVD equipment, ion implanters and lithography machines. The packaging technology for integrated circuit was upgraded and entered the international market. Key materials like polishing material and sputtering targets have been widely applied domestically and internationally.

Large aircraft: passenger airplanes completed and transport aircraft took off

On November 2nd, 2015 the C919 passenger plane rolled off the production line of the Commercial Aircraft Corporation of China in Pudong. The Chinese plane maker has received orders of 514 C919 planes. The successful maiden flight of a large transport aircraft indicated that China has acquired the ability to develop and manufacture transport aircraft with a capacity of 200 tons.

Broadband mobile telecommunication: a full-fledged industrial chain owned by China

A full-fledged industrial chain featuring homegrown TD-LTE mobile communication technology has been developed by China with worldwide engagement. Globally 76 commercial networks have been put into service with more than 1.4 million base stations. Domestic subscribers of 4G service topped 310 million. China has made a quantum leap from 3G to 4G.

Manned space flights and moon probe: remarkable breakthroughs in deep-space exploration

China has launched the Tiangong I spacecraft, the Shenzhou 8, 9 and 10 manned spacecraft, and made three successful dockings. The Tiangong II space laboratory, the Long March 7 rocket and cargo spaceship have been sent into space in preparation for future missions. The successful launches suggested China has mastered the key technologies to design and launch a space laboratory. The Chang'e 3 moon rover successfully landed on the lunar surface. The successful launch of the High-Speed Circumlunar Return and Reentry Spacecraft indicated China has made significant progress in deep-space exploration.

CNC machine tools of China' own

China is now capable of developing 38 types of computer numerically controlled (CNC) machine tools and basic manufacturing equipment up to world-class standards. The mean time between failures for CNC machine tools has more than doubled compared to five years ago. China now exports automated stamping equipment of auto covers to the U.S., and is now able to produce sophisticated equipment like the 80,000-ton forging press and automated tape laying machines.

New drugs: a transition from large-scale manufacturing towards strong R&D

A total of 90 varieties were granted new drug certificates and 135 varieties were qualified for clinical trials. 18 medicines, including Apatinib and inactivated poliovirus vaccine derived from Sabin strain, were approved as original drugs never available on the international market before. Some GLP platforms were certified by international authorities. China's vaccine R&D and antibody expression have caught up with the

international leaders. A new drug R&D and innovation system has been in place, enabling large pharmaceutical companies (whose annual revenue reach 20 million yuan or more from main business operations) to register an annual growth average of 13.4% in industrial output, faster than any other sectors.

Oil & gas prospecting: S&T support for energy security

The HYSY-981 drilling rig, designed and manufactured by China, conducted deep-water drillings in the South China Sea, reaching up to 3,000 meters below the sea level, a much deeper dive compared to 500 meters previously. China developed some advanced equipment like the new-generation cabled telemetry seismic instrument G3i and the 3000HP fracturing truck. Breakthroughs were made in oil & gas geological theories as well as key technologies for exploration, oil recovery efficiency in old oil fields and prospecting under complicated geographical conditions.

Nuclear power: safety ensured and proprietary IP

China developed its third-generation nuclear power plant CAP1400 and was able to manufacture the nuclear island, large forgings and nuclear-grade zirconium products. Everything is set the construction of demonstration. China has successfully produced crucial equipment like the primary helium circulator for the high-temperature gas-coolant nuclear reactor. The world's first commercial nuclear demonstration has been progressing well.

Genetically modified varieties: new achievements

China obtained 137 key genes of prominent breeding values. Total patent grants ranked second in the world; total plantation of pest-resistant transgenic cotton reached 400 million mu (26.67 million hectares). Pesticide use was cut by 400,000 tons equivalent of saving RMB 45 billion. China has established a full-fledged gene breeding system and a bio-safety evaluation system.

Prevention and treatment of infectious diseases: breakthroughs in key technologies

China made breakthroughs in preventing and treating AIDS, hepatitis B and tuberculosis. The country found its own solutions against some diseases incurable in the past. China also developed a proactive rather than reactive prevention & control system to deal with emergent acute communicable diseases and strengthened its ability to tackle epidemics. The Ebola vaccine developed by China marked the first clinical trial of its kind outside China.

Beidou system: among world's top four

China mastered crucial technologies to connect regional and global satellite navigation systems with more than 10 million customers using China's navigation services of an annual output value of RMB 30 billion. Beidou has been recognized as one of the world's top four satellite navigation systems and is enabling steady advancement of China's aviation, electronics and telecommunication technologies.

(Source: Science and Technology Daily, May 31st, 2016)

Upgrade of Industrial Technology

Between 2011 and 2015, China launched a series of transport projects on green vehicles; high-speed rails, integrated transport networks and smart transport systems, and made a number of accomplishments. Within the framework of the National High-tech R&D Plan (863 Program) and the National Key Technology Program, a huge amount of extraordinary achievements were made with the launch of projects on five frontiers - new functional and intelligent materials, advanced structural and composite materials, nanometer materials and instruments, new electronic materials and instruments, material design & fabrication and service safety; aside from six traditional industries and seven strategic emerging industries. In the field of information technology, China aims to build a wireless world with faster Internet access; more effective, intelligent, secured and sustainable technologies. Earth observation and navigation are of strategic importance to sustainable economic growth and social development, so in this area China has developed core innovative

technologies competitive in the international market. Manufacturing is the foundation of a prosperous country. A new round of industrial revolution of smartness and greenness is heralding a new stage of development for the manufacturing sector where China also made quite a few achievements. Special projects on clean coal, smart power grids, wind and solar power enabled technological breakthroughs in coal-fired power generation, clean energy conversion, multi-terminal VSC-HVDC, solar power generation, and some demonstration projects have been launched.

During the five years, China adopted technological innovations along the food industry chain to resolve major challenges, and succeeded in ensuring production increase for 12 consecutive years. Such an accomplishment significantly built up China's overall technological strength and realized food security.

World's first high-speed train running at -40 ºC

By the end of 2015, China had built an extensive network of high-speed rail stretching 19,000 kilometers, accounting for more than half of the world's total high-speed rail. High-speed trains are getting more standardized, smarter and greener.

CNR Changchun Railway Vehicles Co., Ltd. has developed the world's first high-speed train resistant to extreme cold. The train can run at a steady speed of 350km/h with a maximum speed of 487km/h, making it the world's fastest train running at extreme low temperatures of -40℃ .

Integrated innovation: LED city lights

The Ministry of Science and Technology launched the LED promotion campaign in 2009. Up to date, 37 cities have joined the campaign, with 24 million LED lights installed and 7 billion Kwh of electricity saved annually. Driven by the campaign, the LED market has witnessed an annual growth averaging 30% over the five years. The LED industrial output hit RMB 424.5 billion in 2015 with a market penetration of 30%, saving 100 billion Kwh of electricity on an annual basis.

Speed breakthrough: Large-diameter hard-rock open tunnel boring machine

Chinese scientists mastered core technologies regarding high-efficiency rock breaking, high-power synchronous driving, high-efficiency support and key components and manufactured 8m hard-rock tunnel boring machine. The machine has been successfully applied to a power supply project in Jilin, and it has dominated the domestic market and was exported to foreign markets.

The 7m tunnel boring machine was first applied in coal mining after successful resolution of key technological barriers like long-distance downward boring, multi-material high-efficiency dumping and transportation and equipment protection against explosion. The machine can move as much as 639 meters in a month, 4-6 times faster than the traditional mining approach.

Earth monitoring: Science experiment satellite monitors CO2 changes

China made technological breakthroughs in ultra-high spectral resolution remote sensing, complicated satellite guidance and control, high-precision CO2 inversion and assimilation, and developed its first CO2 monitoring satellite and CO2 data processing system. As a result, China has been among the world leaders in the development and application of remote sensing technology to measure the concentration of trace gas.

Connect the future: 5G air interface technology will connect everything

5G is known as the next-generation mobile telecommunication system. 5G research involves a series of crucial technologies, including large-scale antenna array, large capacity base station prototype, network virtualization, and high-frequency large-capacity wireless transmission.

5G SCMA is a technology of non-orthogonal sparse code multiple access. A practical measurement suggests SCMA can triple the subscribers and system gains compared to 4G network without adding antennas or stations, thus enabling connections with almost everything in the future.

Coal-fired generating unit: Overall performance excels foreign peers

The world's first supercritical reheated coal-fired generating unit was put into operation in September 2015, and it has outperformed similar units installed in other countries in terms of power generating efficiency, coal

consumption and environmental protection.

The project, backed by the National S&T Enabling Program, is a demonstration project initiated by the National Energy Administration. Based on the assumption that 4.2 trillion Kwh of thermal power is generated every year, a reduction of 1 gram of coal per Kwh could reduce coal consumption by 4.2 million tons a year and CO_2 emissions by more than 10 million tons.

Breaking record: Bilinear hybrid rice secures food supply

In the 12th five-year plan period, China achieved new breakthroughs in innovating rice breeding technologies and creating a range of new rice varieties with high yield, insect resistance and broad adaptability. Prof. Yuan Longping led a research team to develop the fourth-generation rice varieties. The varieties hit a record yield of 1026.7 kilograms per million mu. The bilinear hybrid rice developed by Prof. Yuan has a total planation area of 700 million mu, bringing an additional economic value of about RMB 40 billion.

(Source: Science & Technology Daily, May 31, 2016)

Public Benefits Brought by Science and Technology during 12th Five-year Plan

During the five years, the Ministry of Science and Technology has been pushing for the application of science and technology to benefit the mass public. Many innovation medicines and medical instruments were used at domestic hospitals and exported to foreign markets. Independent research and development of vaccines has significantly enhanced China's ability to prevent and control major epidemics. Modern technologies played a helpful role in the inheritance and development of traditional Chinese medicine. The establishment of national clinical medicine research centers has expedited coordinated and open innovation in medical research. The R&D of deep-sea vehicle has led to leapfrogging development of ocean resources and exploratory equipment; joint efforts on regional air pollution control has started to show some effects; technologies designed to prevent and control desertification have been widely adopted across areas spanning about 10,000 square kilometers in central and western provinces; the establishment of public security emergency platform has effectively improved our ability to deal with emergencies; green building technologies and standards have helped reduce building energy consumption and improve living environment; smart museums and digital libraries have enriched the content and broaden the width of public cultural services; national sustainable development experimental zones have become important carriers to implement the sustainable development strategy.

World's first artificial cornea hits the market

China developed the world's first artificial cornea with biological engineering technology, and the artificial cornea has been put into production. This would address the acute shortage of human corneas and bring the hope of brightness for numerous blind people whose corneas are damaged. It was the first biological engineering cornea (acellular corneal stroma) independently developed by Chinese scientists, who hold proprietary intellectual property. The world's first and only artificial cornea hitting the market will bring a glimpse of hope that 4 million blind people in China, or even 60 million around the world, might regain vision some day.

Treatment technology for malignant tumor keeps improving

Standardized therapy for esophagus cancer is among the world's most advanced technologies. Chinese doctors have developed early diagnosis and early treatment solutions for esophagus cancer as well as integrated treatment strategies for mid-stage and advanced cancer; medical researchers identified biomarkers for esophagus cancer susceptibility and risk factors, established standardized diagnosis & treatment system, drafted China's first guidelines for standardized diagnosis & treatment of esophagus cancer, early diagnosis & treatment solutions, as well as industry standards for

esophagus cancer diagnosis, and set up the world's largest smart monitoring platform. About 250,000 high-risk people were screened, and the early diagnostic rate of the cancer jumped to 70% from 40%. Standardized therapy has improved patients' five-year survival rate by 5-10%, and long-term curative effect has reached world-leading levels.

China has launched a nationwide program to screen 530,000 women living in the cities to check if they have breast cancer. The program increased the early diagnostic rate of breast cancer. Based on the high-flux gene sequencing technology, China carried out susceptibility tests on high-risk people and proposed an optimized screening plan to improve the diagnostic and therapeutic effect of the commonly-seen malignant cancers.

Let plants "eat" heavy metals in the farmland

China has launched the first demonstration project that aims to restore the polluted farmland. The project covers 1,280 mu (85 hectares) of polluted lands with an average annual cost of RMB 5,000-10,000 per mu and annual income of RMB 400-1,000 per mu. In three to five years the polluted farmlands would become arable again. The technology has been adopted at farmlands polluted by heavy metals in Yunnan, Henan, Hunan and Beijing. In the meantime, practical technologies and equipment have been developed to repair polluted industrial lands, oil fields and pesticide-contaminated farmlands.

Turn urban waste into wealth

China has initiated several research projects to study how to turn wastes into resources and how to produce biomass gas. Scientists and technicians designed 700-ton waste incineration facility and smart control system, developed a set of equipment for automatic rubbish classification, anaerobic fermentation and biomass gas purification, built demonstration projects to dispose of household rubbishes and kitchen wastes and produce purified combustion gas to be transported to urban gas pipeline network or gas stations. Green building materials and household items were also produced from building wastes like coal ash, basalt and metallurgical slag.

Desalted seawater "flows into" power plant

Desalting equipment has been gradually localized and exported to Indonesia and other countries. China has developed the 10,000-ton membrane desalination equipment and innovated the desalination business model. The business model was industrialized in Liuheng Island, Zhejiang Province, and provided practical experience for seawater desalination at island regions. A set of 25,000-ton thermal desalination equipment was developed and applied at several coastal power plants. The newly-developed wind power-desalination equipment and solar power-desalination equipment were successively industrialized, tapping clean energy sources like wind and solar power to purify seawater. The equipment is suitable to be installed at inland, coastal and island regions with clean water and power shortage.

Green buildings feature zero energy consumption

With the implementation of related programs in the five years, China has overcome a series of technological barriers in such areas as building energy conservation, green construction, new planning and design approaches, interior & exterior environment and green building materials, set up a raft of building standards and systems. Over 100 demonstration projects with a combined building area of 21 million square meters were completed. In the field of building equipment and materials, China has developed a batch of advanced technologies with proprietary intellectual property, like energy tower heat pump system, autoclaved aerated concrete blocks, high-efficiency and energy-saving sound insulation vacuum glass.

"Smart" exoskeleton rehabilitation robot

Chinese scientists have developed upper and lower extremities and wearable exoskeletons rehabilitation robots. The upper limb exoskeletons rehabilitation robot, including active and driven exoskeleton, operates with fixed trajectory and a flexible model of exercising; the lower limb exoskeletons rehabilitation robot can help patients take walking exercises through suspended weight reduction and medical treadmill; the wearable lower extremity rehabilitation system integrates a series of functions like online feedback, smart guide and walking training, and through targeted and reasonable amount of exercises and practical ambulation training sessions, the robots can help the limb muscles regain flexibility and improve patients' ability to walk.

(Source: Science & Technology Daily, May 31, 2016)