

# Overview of e-Science Research in China



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**Abstract** During “the 13th Five-Year Plan” period, the Chinese experts and scholars make full use of advanced information technology to carry out scientific research work, and have achieved a series of scientific and technological achievements. It reflects the level of e-Science application in China. This article systematically summarized the e-Science research from three aspects, the application in the frontier research of science and technology, the progress of e-Science in major projects and the achievements of informatization in interdisciplinary. During the past two years, so as to provide a reference for the scholars in this field for the further e-Science research.

**Keywords** E-Science · Informatization · Frontier research of science and technology · Achievements of informatization

## 1 Introduction

The essence of e-Science is the informatization of scientific and technological innovation activities, which is one of the indispensable input elements of modern scientific research [1]. The e-Science is a key of improving innovation capacity and an important means of enhancing national scientific and technological competitiveness. It is also an effective and powerful instrument of promoting transformation of scientific research mode and improving efficiency and output of scientific research.

During “the 13th Five-Year Plan” period, the State Council of the PRC have paid high attention to e-Science and issued the “Outline of National Informatization Development Strategy” [2] which proposed to accelerate the e-Science development. It is the first time for the e-Science work was included in the national strategy. China

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now is developing in a period of important strategic opportunities in which informatization leads overall innovation and creates new advantages of national competitiveness, and also in a key window period in which China develops strong capability in informatization. In April 2018, the secretary general Xi Jinping addressed in the National Symposium on Cyber Security and Informatization [3] that IT application brought opportunities for China. We should flexibly seize the historical opportunity of Informatization development.

For the past few years, China's scientific researchers have conscientiously implemented the deployments of "*Three Directions of Innovation in Science and Technology*" [4]. They accelerated scientific innovation in various fields, positively advanced the work related to e-Science, and achieved a series of new results, effects and breakthroughs. E-Science provides powerful supports for the development of scientific and technological innovation. In order to better introduce and summarize the development trends and results of China's e-Science in the past two years, Chinese Academy of Sciences has continued to coordinate with national related sectors and published *China's e-Science Blue Book 2020*. This book was firstly released in Chinese and English version around the world in order to better display and share major achievements, successful experiences and typical cases of China's e-Science development.

## 2 Overview

*China's e-Science Blue Book 2020* has collected 28 research reports about China's e-Science application in the past two years to introduce development trends, major scientific achievements and progress of China's e-Science, from three aspects of the application in the frontier research of science and technology, the progress of e-Science in major projects and the achievements of informatization in interdisciplinary. In order to provide overall understanding and reference for the readers, this paper introduces the background and extracts the key points of several articles in detail.

### 2.1 *Application in the Frontier Research of Science and Technology*

The basic task or even the primary task of scientific and technological innovation is to face the frontiers science and technology over the world. China has become a scientific and technologically country with great influences, and is constantly developing into a great powerful country in science and technology. Besides, the level of science and technology is also transforming from tracking and learning to parallel and leading. In the past two years, China has achieved a great number of world-class

scientific and technological achievements, in which e-Science has also played an important supporting role.

In the “First Chapter – Application in the frontier research of science and technology”, there are a total of 5 articles included, covering biomedicine, dark matter, high-performance computing, water science, and artificial intelligence. These articles have described many world-class research achievements in science and technology, conducted development trends of the above domains on the future, and elaborated on the important roles played by e-science in those scientific research.

We have extracted 3 articles to introduce in detail.

### 1. The big data of biomedicine advances COVID-19 research.

From the beginning of 2020, an unexpected epidemic broke our peaceful life. In order to win this “battle”, the whole country and even the people all over the world have made great efforts. Domestic and foreign scientists and experts have also rapidly organized scientific strengths to tackle such difficult problem, and positively played the role of think tank, thus making important contributions to fight the epidemic. The paper “*Biomedicine Big Data – Trends and Prospect*” written by Guoping Zhao, an academician of Chinese Academy of Sciences and the chief scientist of Shanghai Institute of Nutrition and Health of CAS, has traced research and development of biomedicine big data (BMBD) and development progress of transformation and application, explored the implications of BMD in sectors such as life science research, medical and health institutions, and biotechnology and biomedicine industries in connection with the challenges and opportunities faced by social and economic development. The recent COVID-19 outbreak is used as an illustrative case study. This paper has summarized an analysis of a decade of BMBD practice, both domestically and abroad. Further depending on China’s national situation, the paper has finally proposed corresponding policies, recommendations and solutions, providing useful reference for China’s biomedical big data administration sectors, research and application sectors.

### 2. “Sunway TaihuLight” guides high performance computing stepping into ExaScale supercomputer era.

The development of high-performance computing comprehensively reflects the scientific and technological strength of a country, and is also an important part of the national innovation system. The paper “*the Progress of China’s High Performance Computing in China and the Development Trends of International High Performance Computing*” written by Zuoning Chen, an academician of Chinese Academy of Engineering, described the landscape of the world TOP500 high performance computers in the past two years, analyzed the latest progress and main shortcomings of China’s HPC research, explained the technological breakthrough and application of “Sunway TaihuLight” supercomputer, and finally discussed the R&D upsurge of Exascale computers in the world. In addition, this paper predicted the future development trends of high performance computing technologies.

### 3. Dark Matter Particle Explorer (DAMPE) has made breakthrough in electrons and high energy cosmic rays observation.

As the first satellite-based observatory of China targeting on astronomical objects, Dark Matter Particle Explorer (DAMPE, also called as “WuKong”) now has operated for over three years on-orbit. It collected and analyzed over 6 billion high-energy cosmic rays (CRs) and obtained hundreds of TB scientific data. Such rich observations have largely benefited the research of electrons (positrons), protons and gammas within the high energy CRs. Therefore, such massive astronomical observation data has presented larger challenges for data storage and processing technology. Chang Jin, an academician of Chinese Academy of Sciences and the president of Purple Hills Observatory of CAS, taken DAMPE for an example in his paper “*IT Application of In-orbit Data Processing for Dark Matter Particle Explorer*”, took a deep insight into DAMPE, introduced the structure and features of its data processing software DAMPE-SW, explained constructions of DAMPE infrastructures that are built on the demand of high data processing performance. This paper summarized the IT application of such scientific satellite in data processing, providing reference for subsequent similar satellite projects in the future.

## ***2.2 Progress of E-Science in Major Projects***

At present, national demands for strategic and scientific supports are more urgent than before. In the course of developing into a world-class in science and technology, we need to focus on national strategy, strengthen the major scientific and technological breakthroughs related to national economy and the people’s livelihood, and make more scientific and innovative achievements related to production and livelihood. In the past few years, new-generation information technologies with representatives of big data, cloud computing and artificial intelligence have flourished. Multiple information technologies have been comprehensively applied in many major projects and achieved excellent results.

In the “Second Chapter – Progress of e-Science in major projects”, there are 12 articles, focusing on development trends of IT application and application of core technologies in scientific research domains. These articles covered scientific investigation in Tibetan Plateau, scientific research over nuclear fusion, lunar exploration projects, cloud computer oriented to scientific research and other aspects of e-Science application.

We have extracted 5 articles to introduce in detail.

1. Big data promotes scientific research over Tibetan Plateau and Pan-Third Pole earth system.

The Pan-Third Pole region mainly includes the Tibetan Plateau and the northern intracontinental arid region of Asia, extending to the Caucasus Mountains in the west and the western Loess Plateau in the east. This region covers 20 million square kilometers and affects the environment inhabited by three billion people. The big data era has brought new opportunities and challenges for us to properly understand and solve environmental problems in Tibetan Plateau and the Pan-Third Pole region.

The paper “*Big data promotes the Tibetan Plateau and Pan-Third Pole Earth System Science*” written by Xin Li, a researcher from Institute of Tibetan Plateau Research of CAS, has introduced the system architecture, data resource integration and big data analysis methods of the Pan-Third Pole Big Data System in detail, advanced big data processing capacity in fields of study, explored a new mode of big data driven geoscientific research, and promoted scientific research over Tibetan Plateau and the Pan-Third Pole earth system.

2. The man made sun “EAST” has realized 1GHW plasma discharge for the first time.

So far, EAST is the only experimental device in the world with similar conditions as ITER and have the best ability to achieve long pulse and high performance operation on the particle balance time scale, which attracts extensive international cooperation and generates a huge amount of experimental data. However, generated massive experimental data has brought new demands and challenges for building IT application environment. The paper “*Information construction and prospect of EAST collaborative experimental platform*” written by Feng Wang, a senior engineer from Institute of Plasma Physics of HIPS of CAS, has introduced the whole process of IT application construction for EAST collaborative experimental platform and outlook for future planning in detail. Besides, The platform not only promoted the accumulation of research resources and improves the work efficiency, but also provided an open and shared way of academic exchange and promotes domestic and foreign cooperative and research.

3. Chinese VLBI network and e-VLBI technology advance lunar and deep space exploration.

The lunar is the first outer planet where human starts exploration in space. Since the beginning of this century, China started its own lunar exploration project, proposed a three-step plan of “circling, landing, and returning”, also known as the Chang’E Project, completed trilogy of lunar exploration projects in 2020. In the Chinese Lunar Exploration Project, Chinese VLBI Network has successfully adopted real-time e-VLBI technology serves the TT&C system in the Chang’E series of lunar exploration missions, providing fast and accurate determination of orbit positioning services during the phases of flying to the moon, orbiting the moon, descending to the moon, and returning to earth. The paper “*Chinese VLBI network and e-VLBI technology applications in Chinese Lunar Exploration Project*” written by Zhong Chen, a senior engineer from Shanghai Astronomical Observatory of CAS, has introduced Chinese VLBI network and e-VLBI technology application in the Chinese Lunar Exploration Project, and details of system development, operation and performance of the VLBI tracking system. Finally, it gives a prospect of Chinese VLBI network for future deep space exploration missions.

4. The new-generation information communication technology 5G promotes to build smart scientific research network.

The Chinese national “the 13th Five-Year Plan” clearly puts forward the requirements and terms of developing and promoting the key technologies of the 5th generation mobile communications and ultra-wideband, and launching 5G commercial applications. As 5G network technology and cloud computing technology constantly develop, combined with current “data-intensive science and research”, the demands for massive data processing constantly increase. Compared with the network resources construction of traditional scientific research institutions, 5G scientific research cloud relies on its excellent network performance, security guarantee and efficient flexible computing resource allocation ability and simple hardware requirements. It can realize the intelligent and flexible construction of computing resources in the face of different needs, localized specialized services, cloud network collaborative optimization and traffic payment, and fully satisfies the stable and high-speed network usage requirements of researchers and students. The paper “*Advanced Scientific Research Environment Evolution and Cloud Service Architecture Design Integrating 5G Technology*” written by Xu Zhou, a researcher of Computer Network Information Center of CAS and the Director of Advanced Network and Technology Development, has introduced the construction requirements of 5G networks and their key technologies and scientific research clouds, and proposed a 5G scientific research cloud architecture. Through the analysis of typical scenarios such as research institutes, large scientific installations, field stations, and university campuses, this paper expounds the practicability and necessity of the intelligent research network constructed by 5G scientific research cloud, and finally summarizes and forecasts it.

5. The national scientific and technical literature’s information guarantee system supports scientific and technological innovation and research.

As an important national strategic resource, scientific and technical literature platform is essential for scientific and technological work and an important supporting system for innovation and development. China’s guarantee level for scientific and technological resources and service capacity will directly influence national innovation and sustainable development in science and technology. The paper “*Development and Services of Resource Discovery System of National Science and Technology Library*” written by Yiqi Peng, the director of National Science and Technology Library, introduced the development of the national scientific and technical literature’s information guarantee system, analyzed current situations and challenges of literature’s information guarantee work, described the proposal of building the national scientific and technical literature’s resources discovery platform, and propagandized the method of finding literature resources.

### ***2.3 Achievements of Informatization in Interdisciplinary***

The scientific research shall not only follow the indomitable spirit, pursue knowledge and truth, but also “benefit the people” and serve economic social development and the people. The scientific and technological level has been one of the main variables

influencing world economic cycle, and also a major factor determining increase of economic aggregate. Since the 21st century, global scientific and technological innovation has been in the unprecedented development period, while new scientific and technological revolution and industrial reform are re-building the global innovation territory and re-shaping global economic structure. The science and technology have never deeply influenced future and destiny of a nation and the people's livelihood like today [5].

In the "Third Chapter – Achievements of informatization in interdisciplinary", there are 11 articles which have described that scientific innovation advances national economic development, industry, agriculture, medicine, education, resources and environment in detail, covering the IT application of China-Russia-Mongolia economic corridor for the Belt and Road, stem cell scientific research, public travel, urban governance, Digital orchard and other domains.

We have extracted 4 articles to introduce in detail.

1. Desertification assessment for China-Russia-Mongolia economic corridor provides IT application supports and decision-making support for the Belt and Road Initiative.

In 2013, the General Secretary Xi Jinping proposed the initiative of co-building the "Silk Road" economic belt and 21st Century Maritime Silk Road [6]. Then, the basic framework for co-building the Belt and Road has been formed. For over six years, the Belt and Road Initiative has promoted fruitful achievements in trade cooperation and significantly advanced economic growth of countries and regions along the "Road" and even the world. The paper "*Implementation of the informatization application scenario for prevention and control of desertification in the China-Mongolia-Russia economic corridor of the Belt and Road Initiative*" written by Juanle Wang, the deputy director of the earth data science and sharing Lab at the Institute of Geographic Sciences and Natural Resources Research of CAS, has analyzed the complex natural geography, fragile ecological environment, and serious desertification of the China-Russia-Mongolia economic corridor in the Belt and Road Initiative; introduced a desertification remote sensing inversion algorithm, a big data application platform, and multi-source data fusion and integration, and established application scenarios for desertification risk control, based on IT application and GIS technology; used modes of big data batch processing and real-time processing, the desertification information along the corridor was extracted, analyzed, and dynamically monitored. Combined with historical data, the diagnosis and testing of desertification patterns and changes within 200 km of both sides of the China-Mongolia Railway (Mongolian section) from 1990 to 2015 have been completed. Besides, the researches have provided IT and decision-making supports for preventing and controlling desertification risks in key regions of the Belt and Road.

2. "One-time Face Recognition System" Drives reform of smart security check mode for civil aviation.

With the surge of civil aviation airport passenger traffic in recent years, the airport security and screening mode is under great pressure, which has become an obstacle

for achieving the target to become a leading civil aviation power. The paper “‘*One-time Face Recognition System*’ Drives Changes in Civil Aviation Smart Security Screening Mode” written by Yu Shi, the director of Intelligent Security Technology Research Center of Chongqing Institute of Green and Intelligent Technology of CAS, has introduced the innovative achievement—“One-time Face Recognition System” which has integrated with multiple advanced technologies and concepts. The system has been applied in Hohhot Baita International Airport and achieved a great success. Besides, the system and the operating procedures have been approved by the authorities, authorizing the use of manually assisted computerized verification to replace the original manual verification, which has started a reform of the civil aviation smart security screening mode in China.

3. The Urban Resources, Environment, and Ecology (UREE) big data platform provides decision-making supports for realizing sustainable urban development.

By the end of 2018, the urbanization rate of China had reached 59.58%. The rapid urbanization has brought a series of social and environmental dilemmas, including urban heat islands, traffic congestion, solid waste, air pollution, lack of essential services and facilities. Therefore, the urban sustainability has become the most significant urban development issue in the world. The paper “*Urban Resources, Environment, and Ecology (UREE) Big Data Platform: Construction and Application*” written by Weiqiang Chen, a professor of Sustainability Science in the Institute of Urban Environment of CAS, has introduced a seven-layer architecture UREE based on open and in-depth data and state-of-the-art technologies, including data acquisition and standardization, data query and visualization, data unified interface and fusion, and urban metabolism simulation. The platform has not only provided powerful technical supports for monitoring and studying dynamic changes of urban resources, environment, ecology and driving mechanism, but also provided decision-making support for solving the Urban Problem in the process of urbanization and how to build the sustainable cities. The UREE is an innovative platform to promote the development and research of urban environment and ecology with big data technology.

4. Digital orchard technology advances intelligent agricultural development.

The Chinese “the 13th five-year plan” explicitly calls for strengthening the integration of agriculture and information technology. In addition, in the “New Generation of Artificial Intelligence Development Plan” released by the state council in 2017, important arrangements were made for the major task of upgrading the intelligent agriculture industry, and pointing out that a number of agricultural integration application demonstrations, including intelligent orchards, should be carried out. In China, fruit industry is the third largest planting industry that after grain and vegetable and it plays an important role in the development of rural economy. The paper “*Present Situation and Development Prospect of the Digital Orchard Technology*” written by Guomin Zhou, the deputy director of the Department of Science and Technology Management of CAAS, has introduced the concept and connotation of the Digital



Orchard, summarizes the research and application status of the Digital Orchard technology, and looks forward to the future trend and key development direction of the Digital Orchard. This would provide reference for advancing development of domestic smart orchard in the future.

### 3 Conclusions and outlook

The year of 2020 is the end year of building a moderately prosperous society in all aspects and completing the “the 13th Five-Year Plan”. During the “the 13th Five-Year Plan”, China constantly follows the development direction of “three orientations” in scientific and technological innovation, which not only strives to realize leaping development in important domains of science and technology, keeps pace with and even guides world development direction in science and technology, supports national strategic demands, but also advances deep integration between science and economic and social development. In the past few years, China has been rapid development in scientific strength, achieved remarkable results, and realized multiple major breakthroughs, including aerospace technology, deep water exploration, manufacturing technology, biotechnology, new energy, new materials, and so on. Meanwhile, the new-generation IT such as big data, cloud computing, mobile Internet, and AI advances rapidly, and e-Science has provided powerful supports and guides for innovation-driven development of scientific research and achievements.

Looking into the world, the future and “the 14th Five-Year Plan”, we have been deeply aware that China lacks innovative capacity, overall scientific development and supporting for economic and social development by science. The new generation of reform in science and technology results in more fierce competition. Therefore, we need to grasp the development trends of the world in science and technology. In order to advance new-generation cross development of scientific technology, we shall focus on building scientific power, further greatly develop information technologies such as big data, cloud computing, AI, and Internet of Things, drive application of disruptive technologies such as quantum computing, carbon-based ICT and block chain in scientific research, deeply integrate with scientific innovation, and play the important role of IT application in scientific and technological development. That will make more contributions to national strategic innovation in science and technology.

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