

浦江创新观察

Pujiang Innovation Observation

2024-18

2024-18

（总第 18 期）

(Issue 18 overall)

上海浦江创新论坛中心

2024 年 9 月 10 日

Shanghai Pujiang Innovation Forum Center

September 10, 2024

编者按：2024浦江创新论坛——前沿科技发展论坛以“前沿技术：塑造未来，创新合作”为主题，邀请国内外各领域专家、政府部门、企业代表围绕前沿技术发展与全球合作展开深入研讨。本期专报对前沿科技发展论坛嘉宾观点进行梳理，供参考。

Editor's note: With the theme of "Frontier Technologies: Shaping the Future through Innovation Cooperation", the Frontier Technology Development Forum under the 2024 Pujiang Innovation Forum invited domestic and overseas experts, government authorities and enterprise representatives from various fields to conduct in-depth discussions on the development of frontier technologies and global cooperation. This special report summarizes the viewpoints of the guests at the Frontier Technology Development Forum for your reference.

2024 浦江创新论坛专报之十一

Special Report 11 of the 2024 Pujiang Innovation Forum

拥抱合作与竞争 聚力推进前沿技术发展 Embracing cooperation and competition, and pooling efforts to promote the development of frontier technologies

随着新一轮科技革命和产业变革加速演进，全球科技创新进入空前活跃期，以人工智能、量子科技、基因技术、新能源、新材料、深海探测等为代表的前沿技术领域方兴未艾，正对整个科技创新体系和人类社会产生深远影响。与会专家一致认为，前沿技术发展为推动时代变革、解决全球问题提供了新的机遇，应加强前沿技术布局研判，发挥企业创新主体作用，以场景牵引加速前沿技术突破，以科技体制机制改革释放创新主体动能，积极探索合作与竞争并存的前沿技术发展新模式。

With the accelerated evolution of a new round of technological revolution and industry transformation, global scientific and technological innovation has entered an unprecedented active period. Frontier technology fields represented by AI, quantum technology, genetic technology, new energy, new materials, deep-sea exploration, etc. are flourishing, and have far-reaching influence on the whole scientific and technological innovation system, and human society. The experts present unanimously thought that the development

of frontier technologies provides new opportunities to promote the transformation of the times and address global concerns. We should strengthen the analysis and judgment of the layout of frontier technologies, give full play to the role of corporate innovation entities, accelerate breakthroughs in frontier technologies with a scenario-driven approach, release the driving force of innovation entities through the reform of scientific and technological institutional mechanisms, and explore new models of frontier technology development in which cooperation and competition coexist actively.

一、前沿技术正在推动经济社会的深刻变革

1. Frontier technologies are driving profound changes in the economy and society

前沿技术正深度赋能千行百业。前沿技术正深刻改变着传统行业的运作模式和发展路径。比如，在医疗、教育、交通、金融、制造业等多个行业中，AI技术的应用不仅提高了生产效率和服务质量，还催生了新的商业模式和产业生态。美国国家工程院院士、香港大学工程学院院长大卫·斯罗洛维茨指出，AI技术帮助我们加速了数据生成和材料设计，预测材料的特性、性能等属性，大大缩短材料设计研发周期。

Frontier technologies are empowering numerous industries deeply. Frontier technologies are changing operation models and

development paths of conventional industries profoundly. For example, in multiple industries such as healthcare, education, transportation, finance, and manufacturing, the application of AI technology has not only improved production efficiency and service quality, but also spawned new business models and industry ecosystems. **David Srolovitz, Member of the National Academy of Engineering and Dean of the Faculty of Engineering, University of Hong Kong**, pointed out that AI technology has helped us accelerate data generation and material design, predict material properties, performance and other attributes, and shorten material design and development lead times greatly.

前沿技术突破将颠覆全球产业格局。当前各领域前沿技术之间互相影响、交叉融合、接力突破，加速新产业生态形成和发展格局重塑。中国工程院院士、中国工程院原副院长干勇指出，AI 技术的尽头是算力，算力的尽头是电力，超级 AI 将成为电力需求的“无底洞”，未来人工智能的发展离不开能源技术的突破。大卫·斯罗洛维茨表示，能源技术的突破将深刻影响航空航天产业，飞机 40% 的重量来自携带的燃料，更加高效和轻便的燃料可以大幅轻量化飞机结构，能源材料的微小变化将带来巨额收益。

Breakthroughs in frontier technologies will disrupt the global industry landscape. Currently, frontier technologies in various fields are interacting, integrating, and relaying in breakthroughs, accelerating the formation of new industry

ecosystems and reshaping the development landscape. **Gan Yong, Academician and Former Vice President of the Chinese Academy of Engineering**, pointed out that the extreme of AI technology is computing power, and the extreme of computing power is electricity, super AI will become an "abyss" of electricity demand, and AI cannot develop without breakthroughs in energy technology in the future. **David Srolovitz** said that breakthroughs in energy technology will have profound influence on the aerospace industry; given that 40 percent of the weight of aircraft comes from the fuel carried, more efficient and lightweight fuel can reduce the weight of the aircraft structure greatly, and small changes in energy materials will bring big profits.

前沿技术将重塑新时代经济社会运行规则。一方面，前沿技术将重新定义解决物理度量与社会问题的规则标准。加州大学伯克利分校教授、加州量子计算挑战研究室主任丹·斯坦普·库恩指出，量子计算机可以解决一些经典计算可能永远解决不了问题，一些理论中提出的新型材料很难直接找到存在证据，量子模拟器技术就可以进行模拟验证。另一方面，前沿技术突破将改变经济运转的底层逻辑。**干勇**指出，新能源产业链供应链的基础建立在矿产资源与材料的开发利用上，进入由新能源驱动的 2050 年“碳中和”时代后，全球经济也会从“燃料驱动”向“材料驱动”转变。

Frontier technologies will reshape the rules of economic and social operation in the new era. On the one hand, frontier

technologies will redefine the rules and standards for addressing physical measurements and social problems. **Dan Stamper-Kurn, professor at the University of California, Berkeley and Director of the Quantum Computing Challenge Institute in California,** pointed out that quantum computers can solve some problems that may never be solved by classical computing, and evidence of existence can hardly be found directly for new materials proposed in some theories, but quantum simulator technology can be used for simulation verification. On the other hand, breakthroughs in frontier technologies will change the underlying logic of economic operation. **Gan Yong** pointed out that the new energy industry and supply chains are based on the development and utilization of mineral resources and materials, and after entering the 2050 "carbon neutrality" era driven by new energy, the global economy will also shift from a "fuel driven" one to a "material driven" one.

二、前沿技术发展的全球趋势和重点方向

2. Global trends and key directions in the development of frontier technologies

新能源与人工智能是当前全球前沿技术发展的核心焦点。干勇指出，当前国际科技与产业竞争主要聚焦在两条线，一是中国建立在新能源优势基础上的未来能源技术，另一个是美国基于算力、大模型领先全球的人工智能技术。人工智能发展高度依赖新

能源和储能技术发展，两条主线将互相交织，影响未来全球竞争格局。中国工程院院士、怀柔实验室主任汤广福指出，清洁能源规模化发展、化石能源清洁化转型、多种能源综合化利用，是推动我国能源由煤炭时代向可再生能源时代转型，实现碳中和目标的关键。要因地制宜推动地热、波浪能、生物质能等能源的多元化发展，减少单一能源依赖。世界工业技术研究组织协会主席、伊斯坦布尔科技大学校长哈森·曼达尔指出，目前人类已经历了六次创新浪潮，当下的第六次创新浪潮被定义为“绿色和数字化转型”浪潮。

New energy and AI are the core focus of current global frontier technology development. Gan Yong pointed out that current international competition in technologies and industries focuses on two lines: One is China's future energy technology based on its advantages in new energy, and the other is globally leading AI technology based on computing power and large models in the U.S. The development of AI relies highly on the development of new energy and energy storage technologies, and the two main lines will intertwine to affect the future global competitive landscape. Tang Guangfu, academician of the Chinese Academy of Engineering and Director of Huairou Laboratory, pointed out that the large-scale development of clean energy, the clean transformation of fossil energy, and the comprehensive utilization of multiple energy sources are the key to promoting the transformation of China's

energy from the coal era to the renewable energy era, and realizing the goal of carbon neutrality. We should promote the diversified development of geothermal energy, wave energy, biomass energy and other energy sources according to local conditions, and reduce dependence on a single energy source. **Hasan Mandal, Chairman of the World Association of Industry and Technological Research Organizations, and President of Istanbul University of Science and Technology**, pointed out that humanity has experienced six waves of innovation, and the current sixth wave is defined as the "green and digital transformation" wave.

生物技术和芯片技术是发展未来产业必需的共性基础技术。在生物技术方面，中国工程院院士、北京化工大学校长谭天伟表示，生物制造工业是最有希望实现可持续发展的技术之一，具有原料可再生、过程环境友好、产物可设计等突出特征，涉及能源、化工、材料、食品、农业、医药等多个国民经济重要行业，预计本世纪末全球 70% 的产品可用生物法生产。在芯片技术方面，中国科协副主席、中国工程院院士、华中科技大学校长尤政指出，微系统技术是超越摩尔时代的重要方向，美欧等国高度重视智能微系统一体化设计等共性基础技术研发，DARPA 专门设有微系统技术办公室（MTO），采取政府主导，以成体系、长周期、高强度的投入方式来引领微系统技术多元发展。

Biotechnology and chip technology are common fundamental technologies essential to the development of future

industries. For biotechnology, **Tan Tianwei, academician of the Chinese Academy of Engineering and President of Beijing University of Chemical Technology,** said that the bio-manufacturing industry is one of the most promising technologies to realize sustainable development, has prominent features such as renewable raw materials, ecofriendly processes, and product designability, and involves many important sectors in the national economy, such as energy, chemicals, materials, food, agriculture, and medicine. It is predicted that 70 percent of products around the world can be produced biologically by the end of this century. For chip technology, **You Zheng, Vice Chairman of the China Association for Science and Technology,** academician of the Chinese Academy of Engineering, and President of Huazhong University of Science and Technology, pointed out that microsystem technology is an important direction beyond the Moore era. The U.S., Europe and other countries attach great importance to the R&D of common fundamental technologies such as integrated intelligent microsystem design. DARPA has a dedicated microsystem technology office (MTO), which leads the diversified development of microsystem technology through systematic, long-term and intensive investment under the leadership of the government.

量子技术发展充满了无限可能性、颠覆性。中国计量科学研究院院长方向指出，量子技术的发展推动 2019 年国际单位制产

生了根本性变革，量子化变革将使无处不在、无时不有的最佳测量成为可能，使一切量的统一成为一种可能。丹·斯坦普·库恩表示，超冷原子技术是一项新兴技术，有望实现量子模拟和量子传感器材料的突破，也可以为广泛的量子信息提供支持，应用前景十分广阔。

The development of quantum technology is full of infinite and disruptive possibilities. Fang Xiang, Director of the National Institute of Metrology, China, pointed out that the development of quantum technology changed the International System of Units in 2019 fundamentally, and quantized transformation will make optimal measurement possible anywhere and anytime, and also make the unification of all quantities possible. **Dan Stamper-Kurn** said that ultra-cold atom technology is an emerging technology that is expected to achieve breakthroughs in quantum simulation and quantum sensor materials, and provide support for a wide range of quantum information, implying an extensive application prospect.

三、相关建议

3. Relevant suggestions

一是探索合作与竞争并存的前沿技术发展模式。前沿技术发展离不开国际合作与开放创新，应以开放市场和国际标准接轨为桥梁越过竞争与隔阂，加快形成制度型开放的科技创新生态。科技部副部长龙腾指出，国际合作是推动科技创新的必选项，只有

持续加强与世界各国的科技人文交流，不断增进彼此友谊，才能完成好科技进步这个世界性、时代性话题。**丹·斯坦普·库恩**指出，量子技术的长期发展和应用存在诸多争论和分歧，进一步突破离不开基础科学的进步，这也是许多国外学者到中国来谋求合作与协同的重要原因。**哈森·曼达尔**指出，前沿技术发展面临的挑战是复杂多元的，只有通过合作才能克服这些困难。

First, explore a frontier technology development model in which cooperation and competition coexist. Frontier technologies cannot develop without international cooperation and open innovation; open markets and international standards should be taken as a bridge to overcome competition and barriers, and accelerate the formation of an institution-based open scientific and technological innovation ecosystem. **Long Teng, Vice Minister of Science and Technology**, pointed out that international cooperation is mandatory for promoting scientific and technological innovation. Only by keeping strengthening scientific and cultural exchanges with countries around the world, and enhancing mutual friendship can we accomplish the global and contemporary task of scientific and technological progress. **Dan Stamper-Kurn** pointed out that there are many debates and differences regarding the long-term development and application of quantum technology, and further breakthroughs cannot be achieved without the progress of basic sciences. That's also an important reason why many foreign scholars

seek cooperation and collaboration in China. **Hasan Mandal** pointed out that frontier technology development faces complex and diverse challenges, and only through cooperation can these challenges be overcome.

二是以场景应用加速前沿技术迭代效率。场景应用可以不断发现技术存在的问题，推动技术迭代升级，拓展应用范围。在新能源方面，**干勇**表示，我国战略新兴产业比重快速增加，为新能源提供了最繁荣的应用场景。在人工智能方面，美国在算法、算力和数据上占据优势，我国应充分发挥应用场景优势，在自动驾驶、智能金融、智慧医疗、制造业等领域加快应用场景落地和成果转化。**尤政**指出，加快推进微系统技术研究的关键在于把设计工具、加工集成装备和技术以及测试应用的场景作为突破口。

Second, accelerate the upgrading efficiency of frontier technologies through scenario applications. Scenario applications can discover technological problems constantly, promote technology upgrading, and expand the scope of application. As for new energy, **Gan Yong** said that the proportion of strategic emerging industries in China is growing rapidly, providing the most prosperous application scenarios for new energy. In the AI field, the U.S. has advantages in algorithms, computing power, and data. China should fully leverage its advantages in application scenarios, and accelerate the implementation and achievement transformation of application scenarios in fields such as autonomous driving, intelligent finance,

smart healthcare, and manufacturing. **You Zheng** pointed out that the key to accelerating research on microsystem technology is choosing design tools, integrated processing equipment and technology, and testing application scenarios as breakthrough points.

三是持续强化企业在前沿技术创新中的主体作用。丹·斯坦普·库恩指出，美国有很多新企业大胆进入前沿技术研究领域，主动参与实验室阶段的技术研发，中国类似企业较少。布达佩斯技术与经济大学校长、电气工程学院院长哈桑·查拉夫表示，匈牙利的研究活动往往通过联合体的方法来组织，其中包括很多小型科技型企业，这些合作能够大幅加快应用场景和系统的开发与迭代的速度。

Third, keep strengthening the role of enterprises as the main body in frontier scientific and technological innovation. Dan Stamper-Kurn pointed out that many new enterprises in the U.S. are entering frontier technology research fields boldly, and participating actively in laboratory stage technology R&D, while there are relatively fewer similar enterprises in China. **Hassan Charaf, President of Budapest University of Technology and Economics, and Dean of the Faculty of Electrical Engineering and Informatics, Budapest University of Technology and Economics**, said that research activities in Hungary are often organized through consortia, including many small technology enterprises, and such collaboration can accelerate the development

and upgrading of application scenarios and systems substantially.

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