复旦大学物理系 物质科学报告

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NEUROMORPHIC COMPUTING

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Data manipulation (memory, computation, communications, data mining) in its many forms drives and fuels our civilization. Modern computation is based on the so-called Turing-von Neumann (TvN) architecture. Revolutionary developments in the past decades in hardware (principally CMOS technology) and software (such as machine-learning) has fueled the ever-increasing capabilities of modern computational machines. It is however agreed that the enhanced computational capabilities will soon (within the next 5-10 years?) slow down considerably due to a variety of issues which are connected probably to the foundation of the TvN type computing. On the other hand, nature has evolved a computational machine (the "brain") which has substantial advantages over conventional silicon based computers. One of the key ingredients in this is the large differences in energy consumption between artificial computers and the brain.

With extensive input from the community, the US Department of Energy convened a group of experts, which developed a report [1] to answer the following basic question:

"Can brain-like ("neuromorphic") computing devices based on new material concepts and systems be developed to dramatically outperform conventional CMOS based technology?"

These types of questions have reached the highest political and economic spheres of the world. As an example recently the US White House announced the Nanotechnology-Inspired Grand Challenge for Future Technology [2]:

"Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain".

In this talk, I will compare the performance and properties of conventional TvN computers and biological computational machines, and will describe at very high level, different approaches proposed to answer the above mentioned challenge.

[1] http://science.energy.gov/~/media/bes/pdf/reports/2016/NCFMtSA_rpt.pdf

[2] https://www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

Ivan K. Schuller，a distinguished professor of physics of University of California San Diego, member of the Chilean, Spanish, Colombian and Belgian Academies has won major science and TV prizes including the American Physical Society (Wheatley, Adler), Materials Research Society (Medal, Somiya), Department of Energy (Lawrence), Department of Defense (Vannevar Bush), European (Humboldt and Lise Meitner) and Regional Emmy. His more than 550 papers and 20 patents established the field of metallic superlattices key for the start of Spintronics, determined the structure of YBCO high temperature superconductor, and established the phenomenology of many hybrid heterostructures. His recent basic research on the properties of quantum-materials has direct relevance for Neuromorphic Computing and Sensors. He was recently elected a fellow of the American Academy of Arts and Sciences.