In Celebration of the 80th Birth Anniversary of Professor HOU Chaohuan

Frontier Explorer, Feat Deliverer

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Sept. 29, 2016 marks the 80th birthday of Prof. Hou Chaohuan, an academician of the CAS, a life fellow member of IEEE and a researcher of IACAS. Despite his senior age, Prof. Hou keeps on swimming to train his body and mind, staying fit and sharp. As one of his former students, in this preface I wish to share his academic experience, his research spirit, and congratulate him on his remarkable achievements. May he keep on opening new chapters in his passionate pursuit of science.

Prof. Hou is one of the leading figures and strategic scientists in the field of acoustics and information in China. He is the honorary president of the Acoustical Society of China. He held the positions of director of Information Science Division of National Natural Science Foundation of China (NSFC), deputy director and member of Standing Committee of Division of Information Technical Sciences of CAS, vice chair of Committee for Consultation and Evaluation of CAS, deputy head of the expert group of information acquirement and processing in National 863 Plan, head of Strategy Expert Committee of Microelectronic Science and deputy director of institute of acoustics, CAS.

Prof. Hou believes that elaboration, originality and persistence are three keys to academic success. He has explored the frontier of science, defied difficulties and proposed many key projects and programs. Having been in charge of a National 973 Plan project (a major special national program) and many other research and development projects, he has accomplished several pioneering and original works. Due to these achievements, he received three national awards for invention, one national award for progress in science and technology (2nd prize), five ministerial awards for progress in science and technology including one special award and one distinguished scientific achievement award from CAS. During his academic career with almost six decades, he has made systematic and original contributions to the development of acoustic and information science as well as Chinese national defense.

Prof. Hou straightforwardly offers advices and suggestions for national strategies of science and technology. His colleagues commented: "approving or opposing, he openly expresses his opinions. All year around, he tirelessly works in the field."

Prof. Hou still goes to his office and guides the research work every day. His wife Mrs. Xiao Youqun is aggressively supportive to his diligence to the development of Chinese defense industry. They used to live apart for more than ten years, sacrificing the joy of living together. Prof. Hou's assiduousness, entrepreneurial spirit and righteous character influence a large group of scientists, encouraging them to strive for excellence.

1 Education

Prof. Hou was born in 1936, Zigong City, Sichuan Province in China. The city is well-known for its salt industry. His father Hou Ceming was a famous patriotic salt merchant, who was enthusiastic in promoting education and was one of the patrons to Shuguang high school in Zigong city. He invited educator Zhang Boling to be the headmaster of the school. Mr. Zhang emphasized the importance of science and engineering education and advocated rescuing the country through education. The school trained a large number of revolutionary youth and scientists. Prof. Hou attended Zigong Shuguang high school and later Chongqing Tsinghua high school. He set his heart to become a scientist to serve his motherland in his teenager years. In 1954, Prof. Hou entered Peking University to study physics.

In 1958, Prof. Wang Dezhao was commissioned by the government to start up Chinese underwater acoustic research work. Thus teaming up acoustic researchers became an urgent task. Premier Zhou Enlai approved selecting 100 best performing students from top Chinese universities to form the first underwater acoustics research team in China. Prof. Hou was one of the selected students. Later on, he started his academic career in underwater acoustic research at the IACAS under the tutelage of Prof. Wang Dezhao and grew up to be a distinguished leading Scientist.

2 Achievements

2.1 Underwater acoustic theory and engineering

In 1959, Prof. Hou took part in Sino-Soviet South China Sea investigation. In 1960, The Soviet Union broke the contract of technology aid unexpectedly. Prof. Hou complied with the requirement to stay at the South Sea research station located in Sanya city in order to improve the methods and technologies left off by the Soviet Union's experts. Through the experiments and investigations, he accomplished the project of "The Survey System for Fluctuation-Statistical Properties of Acoustics Signal", which pushed forwards the research in the fields of both acoustic signal and reverberation in China. For this achievement, He won the national prize for invention in 1965.

In 1965, Prof. Hou was invited to join a panel on importing target detection technology. He pointed out that the existing schemes were impractical due to the backwardness of Chinese manufacturing capability. He put forward a new proposal despite other expert's challenges, in which he presented the "Phase-shift Multi-beam Array Signal Processing System", providing a new design model for detection. He also finished the system's overall analysis, theoretic calculation, parameters selection, optimization design and performance estimation. Finally, he won the competition, and received an award at the national science and technology convention. This proposal was applied in a key project, which was awarded the third national prize for invention.

In 1980s, Prof. Hou anticipated that the information technology would prompt the digital information processing so as to push the design of underwater acoustic engineering into a digital

and intelligent era. He was the first to complete the intelligent underwater information processing system in China. Based on the digital design, the system made a breakthrough of performance in underwater signal detection, noise passive ranging, and precise control *et al.* This project won a special award from CAS. He became a research pioneer of Chinese acoustic guiding system.

Since 2000, Prof. Hou has been holding the position of general designer of light intelligent UUV in a national key project. From the system to algorithm, he flung all his energy into every aspect of the research. Even when he was in his 70s, he still took part in lake and sea trial. He led the research team to conquer many difficulties and make some important breakthroughs in the overall design, underwater signal detection and recognition, rapid and accurate control, autonomously route planning and so on, which accelerated this industry to have a stunning development. The overall performance of the UUV reached a worldclass level and the product became a hit in China. This project won the second national award for progress in science and technology. Prof. Hou's work put forward a big progress for the light UUV industry.

2.2 Information processing area

Prof. Hou realized that the speed of information processing was the bottleneck in underwater engineering project. Although his major was physics, he took the lead in information processing research instead of waiting for the outcomes from others.

He firstly started the research of the array processing and system integration in China, and foresaw that the system would be integrated on a chip in near future. He proposed the scheme of array processing on a chip and finished the DSP-1 Array processor (supported by National 863 Plan). The chip was applied in acoustic engineering efficiently. He pioneered the research of Very-Large-System-Integration (VLSI) and accomplished a chip with 15 computing nodes in array structure.

In 1987, he promoted building the laboratory of system integration, which is completed in 1994 with a support from a National 863 Plan. Later, the laboratory finished the designs and manufactures of three chips for Chinese acoustic engineering, including FFT, DBF, and QRD-RLS. Due to these distinguished work, he was awarded a prize by the national 863 Plan group.

During 1999-2004, as the chief scientist, he presided over one of the National Basic Research Program projects, "a DSP&CPU Chip with Reconfigurable Architecture to Function in Software Systems". In this project, the functions of DSP and CPU were combined by the methods of software and hardware, and the performance was improved greatly. The product was called Processor Super V, which achieved tape out under the domestic 0.18 μm CMOS manufacturing technique and realized multiple Very-Long-Instruction-Word and Single-Instruction-Multiple-Data structure based on reconfigurable theory. In 2010, Prof. Hou became an adviser to guide the project of "high performance and low consumption embedded DSP" supported by "core electronic devices, high-end general chips and basic software products" project.

From theoretical physics to underwater engineering, information processing, chip design and system integration, Prof. Hou challenged the new research area in pace with the national need and the scientific development. Each research fruit was the result of more than ten-year

devotion. For his achievements, he was praised some outstanding titles, such as the National Middle-age Expert with Remarkable Contributions in 1988, the National Advanced Worker in 1989, Academician of Chinese Academy of Sciences in 1995, and the Outstanding Contributor of the Distinguished Scientific Achievement Award in Chinese Academy of Sciences in 2013.

3 Forethought

Prof. Hou earnestly took part in national scientific strategy planning. He suggested the research of high-speed information processor in the National 863 Plan. From 1987 to 1992, as the depute head of experts team, he took in charge of the subject of high-speed and high-accuracy realtime information processing in the field of information acquirement and processing. He designed the roadmap, set the technical targets, organized the research resources nationwide, and eventually fulfilled the plan.

From 1997 to 2006, Prof. Hou took over the Information Science Division of NSFC as a director and put several scientific actions into practice. He foresaw that the internet would bring disruptive influence in research and education. He advocated building NSFCNet including CAS, Peking University and Tshinghua University and so on, so that these institutes and universities can share resources and exchange information with institutes abroad. He persuaded the NSFC to provide 20 million yuan, exceeded the existing maximum aid of 5 million yuan. In addition, he also gained the support from the universities, amounting to 6 million yuan. So then first national high-speed demonstration network was built and could be connected with institutions abroad. Several international conferences were held through the network. Facing the need of expanding the network, Prof. Hou asked other academicians to call for support from the central government to build a new larger-scale high-speed network for science and education. After approval, the second generation of high-speed demonstration network was built in 2004 supported by several ministries together.

Prof. Hou realized that System-on-chip (SoC) was the next step of integrated circuit according to Moore's law. In 1999, he organized the forum of the future of SoC together with universities, industries and NSFC. As a consequence, the key scientific project "Basic research of semiconductor integrated chip system" gained approval and support by the NSFC. And he led the expert team of this project.

Due to the fact that the distributed underwater mobile sensor network was still in its infancy in China, Prof. Hou launched the NSFC forum "national strategy needs and key scientific problems of underwater network" in 2013. In 2016, He presided over the strategic research of underwater sensor network in order to push the construction of integrated information network of space, air, land and sea, and to explore the scientific frontier and national needs. There will be many applications for this research, such as marine information realtime monitoring and share, marine data collection, environment monitoring, disaster prevention, offshore exploration, navigation assist, distributed surveillance and mine reconnaissance *et al.*

4 Nurturing talents

Prof. Hou always pays more attention to nurture talents, and believes that the talents grow

from participating in projects. He has supervised more than 120 graduate students, many of whom hold important positions in academic institutions or high-tech companies. He was also a guest professor in many universities such as University of Science and Technology of China, Tshinghua University, and Nanjing University *et al*. For his contribution to education, he received the titles of "excellent supervisor" of CAS in 1990 and "outstanding teacher with remarkable contribution" of CAS in 2008. In his research team, Prof. Hou encouraged the youths to undertake challenging tasks. For example, in a national 973 project, the average age of all subproject team leaders was no more than 35 years old. Under his guidance, the laboratory where he once took charge of gained the title of Advanced Group from CAS and has become a key laboratory of CAS. The laboratory has proved to be a front-runner of Chinese UUV research. All members in the laboratory will stick to Prof. Hou's spirits of originality, conscientiousness, persistence, enterprise and make more contributions for the sake of fulfilling the dream of strong ocean nation.

Appendix:

直立潮头 建功卓著

——贺侯朝焕先生八十华诞

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2016 年 9 月 29 日是中国科学院院士、IEEE 学会终身会士、中国科学院声学研究所特聘研究员侯朝焕先生八十华诞。先生虽然已至杖朝之年，仍然坚持游泳锻炼，体魄矫健、思想敏锐，作为侯先生的弟子，仅以此文回顾先生的科研经历，学习他的治学精神，恭贺先生卓著成就，也祝愿他继续在他热爱的科学事业中健康耕耘，再谱新章。

侯朝焕先生是中国声学和电子信息领域的领军科学家、战略科学家，是中国声学学会的名誉理事长，曾任国家自然科学基金委员会信息科学部主任、中国科学院信息技术科学学部常务委员会副主任和学部咨询评议委员会副主任、国家 "863" 计划信息获取与处理技术专家组副组长、中国科学院微电子战略指导委员会主任、中国科学院声学所副所长。

侯朝焕先生在学术研究中秉执 "选准方向，独树一帜，锲而不舍，定有成效" 的治学理念，放眼世界科技前沿，勇立潮头，提出多项重大工程和项目的建议，在担任国家 "973" 项目首席科学家、国家重大专项工程总设计师等多项国家重大研发项目负责人过程中，身体力行，完成了多项开拓性、创新性研究，获 3 项国家发明奖、1 项国家科技进步二等奖和 5 项部院级科技进步奖 (含中国科学院特等奖 1 项、中国科学院杰出科技成就奖 1 项) 。在近六十载的科研生涯中，侯朝焕先生为我国水声学和信号与信息处理领域的发展以及国防建设做出了系统性和创造性的突出贡献。

侯朝焕先生在工作中耿直率真，多次为国家的科技发展规划建言献策，同事评价他 "顺也直言，逆也直言，坦荡心胸真君子；春也耕耘，秋也耕耘，辛勤操劳唯丈夫。"

侯朝焕先生现在仍坚持到声学所上班，指导科研工作。他的夫人肖幼群女士在两人婚后异地工作十多年，克服了家庭的极大困难，理解他甘于为国防科技事业奉献的赤子情怀。侯

先生孜孜不倦、锐意进取的科学精神和为人正直、矢志报国的高尚品德，教育和影响了一大批优秀的科技人才，也将激励着年轻后学奋发有为。

1 求学经历

侯朝焕先生于 1936 年出生在四川省自贡市。自贡以井盐闻名天下，其父亲侯策名先生是当地著名的爱国盐商。侯策名先生非常重视地方子弟的教育，出资兴办了四川自贡蜀光中学，并邀请爱国教育家张伯苓先生出任校长。张伯苓先生办学中注重理工科教育，提倡教育救国，从自贡蜀光中学走出一大批革命青年和科学家。侯朝焕先生在自贡蜀光中学和重庆清华中学接受了良好的初高中教育。在进步教育的影响下，侯朝焕先生形成了科技报国的志向。1954 年，他以优异的成绩考入北京大学物理系。

1958 年，国家希望汪德昭先生主持新中国国防水声学研究的创建工作。由于组建队伍的需求非常迫切，经周恩来总理同意，从全国几所重点大学物理系遴选品学兼优的 100 名差半年到一年毕业的大学生，提前分配到中科院参加水声研究工作，边学边干。人们把这一举措称为 “拔青苗” 。侯朝焕先生作为百名 “青苗” 中的一员，参加到由汪德昭先生领导的水声学研究工作中，与水声学研究结下了不解之缘，从我国第一批水声学科研工作者中脱颖而出，成为该领域的领军科学家。

2 科研建树

2.1 水声理论及工程研究

1959 年，侯朝焕先生参加了中苏联合南海水声考察。令人料想不到苏联在 1960 年单方面撕毁与我国签订的技术援助合同，中止了水声学合作研究。他服从组织安排，留在了当时生活条件极其艰苦的三亚南海研究站。他开始对苏联专家留下的方法和技术提出改进意见，通过大量的海上水声物理实验和考察，完成了 “声信号起伏统计特性测量和分析系统” 的研制，推动了水声信号场和噪声、混响场的研究。1965 年，该项成果获得了国家科委颁发的发明证书。

1965 年，侯朝焕先生受邀参加关于目标探测技术方案的引进评审会。在会上，他大胆指出我国当时的生产制造水平难以实现引进方案，同时引进方案也存在不足之处。面对其他专家的质疑，他随即提出新方案，与引进方案竞争。他创新性地提出了 “相移多波束基阵信号处理系统”, 给出了该系统的全面分析、理论计算、参数选择和优化设计以及性能估计，实现了水下探测系统设计思想的重大跨越，并在最终的方案对比试验中胜出。该项成果获得 1978 年全国科技大会奖，随后成功应用于工程项目，获得了显著的社会和经济效益，于 1987 年获得国家发明三等奖。

早在 80 年代，侯朝焕先生敏锐地察觉到数字信号处理将随着计算机技术的发展对水声工程设计带来变革性的影响，工程设计将走向数字化、智能化。他在国内率先设计完成智能型水声信号处理系统，该系统基于数字化设计，在水声信号检测和定位、噪声被动测距、精确控制等方面取得性能上的大幅突破，该项目 1996 年获中科院特等奖。这项科研使他成为我国声场匹配领域引入智能化处理方法的开拓者，我国水声智能制导系统研制的开创者。

进入 21 世纪，侯朝焕先生担任国家重大任务轻型智能水下航行器研制的总设计师。作为技术总负责人，他事必躬亲，大到系统方案设计，小到电路设计与算法实现，都倾注了他无数的心血，甚至已进入古稀之年，仍亲临湖、海试验现场，带领团队攻坚克难，在航行器

总体设计、水声信号检测、水下目标识别、快速精确控制、航行路径自动规划等方面取得突破，最终实现了我国在该行业的跨越式发展，总体性能和主要指标达到了国际领先水平。该项目于 2014 年获得国家科技进步二等奖。侯朝焕先生敢为人先、不断开拓创新，引领了水下航行器行业升级换代的发展。

2.2 信号与信息处理领域研究

多年的水声工程设计让侯朝焕先生认识到信号与信息处理速度是决定水声工程运行效率的瓶颈。作为研究物理出身的他没有坐等信号与信息处理领域的成果，而是把握了该领域发展的脉络，自己挑起大梁，率先进行创新性研发。

他最早提出开展阵列处理和系统集成的研究，并预见到信号处理系统必然会集成到单个芯片上去。他提出了在单个芯片上实现阵列处理结构的方案，基于方案于 1991 年研制完成 “DSP-1 阵列信号处理机” 项目 (国家 “863” 计划项目)。随后应用于声学工程项目，效果明显。

他在国内率先开展了超大规模集成电路 (VLSI) 信号处理研究，将信号处理算法集成到高速芯片上，1993 年首次在单个芯片上实现了 15 个运算节点阵列结构的信号处理芯片，达到当时的国际先进水平。1987 年初，他提出了建立国内系统集成实验室的具体设想，并列入 “863” 项目，在国内外信号处理和芯片集成领域产生了重要的影响。该实验室于 1994 年建立完成，同时完成了具有自主知识产权的从算法到版图自主设计的全定制 FFT (快速傅里叶变换) 、DBF (数字波束形成) 、以及 RLS (递推最小二乘滤波) 等三个芯片的设计，并一次投片成功。由于以上出色工作，他 2001 年被授予 863 信息获取与处理先进个人称号。

随后，他又提出了 “面向功能可重组结构的 DSP&CPU 芯片及其软件的基础研究” 项目建议，并于 1999 年在国家 “973” 计划中立项，他担任该项目的首席科学家。该项目将面向不同应用的 DSP 和 CPU 芯片结构有机地结合在一起，通过软硬件协同优化，构成一个简捷、高效的体系，最终成功研制出 “华威” (Super V) 处理器，并基于国内 0.18 μm CMOS 工艺流片。华威处理器芯片具有完全自主知识产权，既有 DSP 功能，又具有 CPU 功能，以及统一的兼顾 DSP 和 CPU 的高效指令集。2010 年，他又作为顾问指导了核高基项目 “高性能、低功耗、嵌入式 DSP” 的研究。

从理论物理到水声工程，再到信号处理，随之又转移到芯片设计和系统集成，每一次挑战新研究领域，侯朝焕先生或是解决国家急需或是抢占科技前沿，每一项成果的获得都是十年磨一剑的坚持。由于侯朝焕在科研工作中所取得的出色成就，1988 年人事部授予他 “国家级中青年有突出贡献专家” 称号，1989 年国务院授予他 “全国先进工作者” 称号，1990 年被评为中央国家机关 “优秀共产党员”, 1995 年，增选为中国科学院信息技术科学部院士，2013 年评为 “中国科学院杰出科技成就奖突出贡献者” 。

3 登高望远

侯朝焕先生积极参加我国科技战略规划工作。他在国内最早提出开发高速信号处理机的重要性和必要性，并就此事上书给当时的科技部长朱丽兰，朱部长请专家对他的建议进行了进一步论证后欣然采纳，将其纳入了 “863” 计划。他则于 1987 年 7 月至 1992 年 11 月，受聘担任 “863” 信息获取和处理技术专家组第一届、第二届专家组副组长，主管国家信息获取与处理技术领域 “高速高精度实时信号处理” 专题的高技术发展工作，与其他专家共同制定了超高速实时信号处理及超高速集成电路设计专题目标及技术路线，组织全国性的攻关，实现了原定的预期目标。

侯朝焕先生从 1997 年至 2006 年担任了国家自然科学基金委信息科学部主任，实施了多项影响我国信息科技研究发展的重要措施。他早在 20 世纪 90 年代初预感到互联网必将在未来的科研和教育中发挥颠覆性作用，就向国家自然科学基金委提出创建 “新一代高速信息示范网 (NSFCNet)” 的建议，将中科院、北大、清华等几所大学纳入其中，这样可以在实现资源共享的同时，还可以实现与国外相关机构进行零距离的学术交流。但要建成这个网络，需要筹集 2600 万的资金，由于资金数目过大，基金委没有先例。按照既成惯例，基金委最多只能批 500 万，但在侯朝焕先生的再三 “游说” 下，基金委张存浩主任为他的有关高速信息网的前景所吸引，决定为他破一回例。于是，他们去说服基金委其他几位副主任，基金委最终拿出 2000 万作为高速信息网的经费，而中科院、北大、清华等几个科研院所合力筹资 600 万。就这样，在侯朝焕的奔走下，第一代国家高速信息示范网于 2000 年建成，并与美国等国际科研机构实现同步联网，成功举行了几次国际网络会议。随着第一代高速信息网在国内影响的扩大，其他的一些院校纷纷加入其中，网络面临着扩容的需要。在这种情况下，侯朝焕又发起 47 名院士联名向中央领导建议，建立大规模的新一代高速科学教育网。该建议很快得到中央领导的批示，最终经发改委、信息产业部和基金委等多个部门联合建立国家第二代高速示范网，并于 2004 年投入使用，使我国的互联网发展迈入了国际水平。

侯朝焕先生敏锐地洞察到 SoC 是 21 世纪集成电路的发展方向，是微电子技术按摩尔定律发展的必然结果。1999 年在国家自然科学基金委的支持下，与来自科研院校、产业界、基金委等单位的 60 余位专家学者共同探讨了我国 SoC 领域的发展方向。经过多次认真论证，他牵头完成了《半导体集成化芯片系统基础研究》重大研究计划建议书和计划实施规划书，并于 2002 年获得国家自然科学基金委批准立项。侯朝焕先生担任该重大研究计划的指导专家组组长。

侯朝焕先生基于我国分布式水下移动传感网络处于探索阶段的现状，于 2013 年发起了国家自然科学基金委 “水下信息网络的国家战略需求和关键科学问题” 的学术论坛，于 2016 年主持中国科学院学部学科发展战略研究 “水下传感器网络” 项目，旨在推进空、天、陆、水网络一体化建设，理清水下传感器网络研究的国际科技前沿问题与国家重大战略急需，以实现海洋信息实时监测与共享，在环境监控、灾难预防、辅助导航等方面发挥广泛作用。

4 人才培养

侯朝焕先生十分重视科研人才的培养。他以项目带学科、以项目育人才的人才培养思路，在中国科学院先后培养硕博士 120 余名，还曾兼任中国科技大学、清华大学、南京大学、北京航空航天大学、重庆大学客座教授。培养的学生中其中不乏行业精英，如国家青年拔尖计划获得者、国家重大科研项目负责人等。由于他在人才培养方面的成就，1990 年被中科院教育局授予 “中科院优秀研究生导师” 称号，2002 年被中科院研究生院聘为终身教授，2008 年获得了中国科学院 “杰出贡献教师” 荣誉称号。在研究团队中，侯朝焕先生敢于给青年科研人委以重任、鼓励他们成长，为后续发展储备了人才。他所主持的 973 项目，除他一名院士外，各课题组长的平均年龄不到 35 岁，这在 973 项目中极为少见。侯朝焕先生所在的实验室，在其指导下 2010 年曾获得中国科学院 “先进集体” 称号，2014 年被评为中国科学院水下航行器信息技术重点实验室，已成为我国声学智能制导和轻型水下无人航行器设计人才培养的重要基地之一，具有一支集基础、应用和开发研究于一体的科研队伍。这支队伍将在侯朝焕先生的影响下，一如既往地坚持创新精神、严谨作风，奋发努力，不断进取，为实现海洋强国梦做出更大贡献。