

Curriculum Vitae

Bo Wang

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A. PERSONAL



A.1 Name.

Bo Wang

A.2 Degrees.

B.S., Physics, Shanxi University, Taiyuan, China, 1998-2002

PhD, Optics, Shanxi University, Taiyuan, China, 2002-2007

Thesis: "Investigation of the Nonlinear and Quantum Effect in the Coherent Atomic Medium"

Thesis Advisor: Prof. Hai Wang

A.3 Positions at Tsinghua University.

Assistant Professor, Department of Precision Instrument, 2010-2012

Associate Professor, Department of Precision Instrument, 2012-2016

Tenure-track Associate Professor, Department of Precision Instrument, 2016-2018

Tenured Associate Professor, Department of Precision Instrument, 2018-present

A.4 Positions at other institutions or organizations.

Postdoctoral Research Associate, Max-Planck Institute for the Science of Light, Germany, 2007-2010.

A.5 Licenses, registrations, and certificates.

IEEE Senior Member, ID# 92227426

OPTICA Senior Member, ID# 943091

B. PROFESSIONAL OBJECTIVES

B.1 Candidate's own statement of professional objectives and contributions.

Objective 1. Impactful and Sustainable Research on Precision Measurement of Time and Frequency.

Prof. Wang's research highlights the principle and technological innovation on the time and frequency measurement, dissemination and synchronization. Besides, he is diligent in promoting the application of these technologies in the field of time keeping, and radio astronomy. He proposed a precise and continuous time and frequency synchronization method (Scientific Reports 2012). To increase coverage of the highly synchronized time and frequency signal, he proposed and demonstrated a series of multiple-access time and frequency synchronization method (Optics Letters 2012, Optics Letters 2013, Chin. Phys. B 2016 and 2017), and the free space frequency synchronization method (Review of Scientific Instruments 2013, and 2015). He developed a fiber delay measurement method (Optics Express 2016, Review of Scientific Instruments 2016, 2018), which has pushed the fiber delay measurement accuracy to 0.2 ps with a 0.1 ps measurement resolution and a large dynamic range up to 50 km as well as no dead zone. Recently, absolute phase synchronization over optical fiber is demonstrated (Optics Express 2020). A repeatable phase difference regardless of restart operation and fiber route changing between the phase standard at local site and the recovered signal at the intermediate access node is achieved.

Professor Wang is also very active in the international collaboration. He contributes to the international large scientific facility-SKA (Square Kilometer Array) in the design process since 2013, and the proposed frequency synchronization solution was successfully adopted for SKA-LOW telescope on 9th October 2017 after a technical down-selection. He serves as the work package leader of frequency synchronization system for SKA-LOW, leading the Detailed Design Document preparation work and passed the critical design review (CDR) of the SKA Organization on 16th May 2018. The principle and technology innovations during the SKA collaboration have been published as peer-reviewed journal papers (Scientific Reports 2015, Chin. Opt. Lett. 2015 (Front Cover)). Furthermore, some papers are co-authored with the international collaborators (Chin. Opt. Lett. 2018 (Front Cover), Astronomy Reports 2017, IEEE Photonics Journal 2021). In 2021, the fiber based frequency synchronization devices have been purchased and applied in the e-Merlin telescope array running by Jodrell Bank Observatory, UK

To promote the application in the field of time keeping, Professor Wang collaborated with National Institute of Metrology, Beijing Satellite Navigation Center, and Beijing Institute of Radio Metrology and Measurement, and constructed the Beijing Regional Fiber Synchronization Network using the self-designed frequency synchronization devices. With this network, the real-time and continuous time and frequency comparisons between timekeeping clocks of 4 different institutions have been realized in his lab. It can be served as the pathfinder of the China National Time and Frequency Network. Recently, a very interesting work- Correlation Measurement of Co-Located Hydrogen Masers (Metrologia 2018), and the Real-time free-running time scale with remote clocks on this network (Metrologia 2019) have

been investigated. Furthermore, a new research direction- the phase sensitive vibration detection based on fiber network has been carried out, and the preliminary result has been published (Optics Express 2021).

Ever since his promotion to Associate Professor in 2012, Professor Bo Wang has been engaging in quality original research activities and has published 28 peer-reviewed journal papers, in Optics Letters, Optics Express, Metrologia, Scientific Reports, Review of Scientific Instruments, and others. Since 2012, Professor Wang has been awarded funding over CNY 25 M (\$ 4 M). Prof. Wang won the Scientific and Technological Progress 1st class Award of Chinese Society for Measurement, the Important Achievement Award of Optics in China (10 works are awarded each year), and the Editor-in-Chief Choice Award of Chinese Optics Letters in 2016 (2 papers each year). Prof. Wang is the senior member of OSA and IEEE. He serves as the reviewer of IEEE and OPTICA publications. He serves as a member of the expert panel of China National Time and Frequency Network System. He is also serving as the vice director of the Institute of Instrumental Science and Technology, and the Key Laboratory of Photonic Measurement and Control Technology of Ministry of Education at Tsinghua University, which has nearly twenty professors in the direction of measurement and control technology. This shows Prof. Bo Wang's passion and dedication to research in precision measurement of time and frequency as an emerging leader in the discipline.

Objective 2. Engagement in Student Training and Education.

Professor Bo Wang made a major effort to organize the teaching. He introduced two new undergraduate courses. The 1st new course is Quantum Metrology: Principle and Application, and it was introduced to undergraduate students because that a fundamental change is happening to metrology, especially to the redefinition of 7 basic SI units. It also attracted students from Department of Physics. The 2nd new course is “Experimental Exploration of Measurement and Control Technology & Instrument (EEMCTI)”. It was introduced to the freshman of the school of mechanical engineering, and was awarded by Tsinghua University teaching grant (CNY 180 K). He has developed the lectures and the on-line homework for these courses. Professor Wang has supervised or co-supervised 1 MS and 13 PhD students. He also sponsored multiple undergraduate students through the Tsinghua Students Research Training (SRT) Program and currently has mentored 13 undergraduate students. Through the SRT training, some of undergraduate students have got the further funding support from government. Yuchen Wang, Han Ma and Linyun Zhang have got the National Undergraduate Innovation and Entrepreneurship Training Program funding support. Wensheng Yang and Yixin Ling, Bohan Zhang and Haiqing Hao have got the Beijing College Students Scientific Research and Entrepreneurial Action Plan funding support. Professor Wang was awarded the “KLA-Tencor Teaching and Educating Award” in 2018, Tsinghua-XCMG Faculty Scholarship in 2019, and the Excellent Head Teacher of Tsinghua University in 2020.

Objective 3. Development of Collaborative Programs.

Professor Wang realized the importance to extend the technology boundary and widen the potential applications of his technology by tightening collaboration with others. He has established collaborations with both Chinese and International researchers. Professor Wang has been deeply involved in the international large scientific facility-SKA, and collaborated with the researchers from UK, Australia, Netherland, South Africa, India, and so on in the frame of SKA-Signal and Data Transfer (SaDT) consortium, and has published co-authored papers (Astronomy Reports 2017, Chin. Opt. Lett. 2018 (Front Cover), IEEE Photonics Journal 2021). His multilateral cooperation has been supported by the international S&T cooperation program of MOST (CNY 9.68M). He serves as the work package leader of the frequency synchronization system for SKA-LOW, leading the Detailed Design Document preparation of the work package which has passed the critical design review (CDR) of the SKA Organization. In addition to international collaboration, Professor Wang also collaborated with professors in China. He participated in the major instrumentation development projects of MOST (Development and application of the Cesium fountain primary clock) in collaboration with Prof. Tianchu Li, Prof. Fang Fang and Prof. Aimin Zhang of National Institute of Metrology, Prof. Desheng Lv of Shanghai Institute of Optics and Fine Mechanics, Prof. Chunhao Han of Beijing satellite navigation center, and Dr. Ruifeng Zheng of Hwa create Inc. As the PI of National Key Project of Research and Development, he collaborated with Prof. Jianye Zhao of Peking University, and researchers of the Beijing SUPLET company to develop the SKA required frequency synchronization devices.

Objective 4. Commercialization of Technologies Developed in Research.

Professor Wang has 10 Chinese patents (co-inventor) issued and 3 pending, in which 6 have been licensed to Beijing General Testing Technology (BGTT) Inc. The translation of the 6 patents on the time and frequency measurement method and system, together with 2 other patents on gravity meter (patented by his colleagues) has been valued at 20.116 million CNY, and accounting for 40% shares of the BGTT Inc. He also collaborated with the Beijing SUPLET company on the development of fiber based frequency synchronization device, especially the special design for SKA. .

B.2 Honors and awards.

- [1] Excellent Head Teacher of Tsinghua University, 2020 and 2022
- [2] Tsinghua-XCMG Faculty Scholarship, 2019
- [3] KLA-Tencor Teaching and Educating Award, 2018
- [4] Scientific and Technological Progress Award, First Class, Chinese Society for Measurement, 2016
- [5] 2015 Editor-in-Chief Choice Award of Chinese Optics Letters, 2016
- [6] 2015 Important Achievement Award of Optics in China, Chinese Laser Press, 2016
- [7] Beijing Higher Education Young Elite Teacher Project, 2013
- [8] Outstanding Oral Presentation award on the 4th China Satellite Navigation Conference, 2013

[9] The 12th Experimental Technology Achievements of Tsinghua University, Second Prize, 2012

[10] The Excellent Doctor Degree Dissertation in Shanxi Province, 2007

B.3 Memberships in academic, professional and scholarly societies.

[1] Institute of Electrical and Electronics Engineers (IEEE), Senior Member

[2] OPTICA, Senior Member

[3] SPIE, member

[4] Full member of Signal and Data Transport (SaDT) Consortium of Square Kilometre Array (SKA), 2013-2020

[5] Work package leader of the frequency synchronization for SKA-LOW, 2017-present

[6] SKA Consultant Leads committee member, 2018-present

C. TEACHING

C.1 Candidate's own statement of contributions to teaching. (written in the 3rd person)

Prof. Bo Wang has made a major effort to perform teaching at Tsinghua University. He has introduced 2 new undergraduate course. He received positive student evaluations and favorable peer teaching evaluations from senior Professors. His contributions were recognized by receiving a number of department and university rewards and honors. In 2018, Professor Wang was rewarded the “KLA-Tencor Teaching and Educating Award” by the department (1 per year), and awarded by Tsinghua University a teaching grant (CNY 180 K) to innovate one of his courses.

- Quantum Metrology: Principle and Application (No. 40131272)

Professor Wang has introduced this new course at Tsinghua University and has been the principle lecture of this course since 2016. The course has 32 class hours, and it was introduced to undergraduate students because that a fundamental change is happening to metrology, especially to the definition of 7 basic SI units. The current SI defined in terms of artifact will be replaced by the natural quantum standards definition based on quantum physics on the 26th CGPM when it convenes in November 2018. Consequently, Professor Wang has designed the course for undergraduate students to better understand this innovation in the metrology field. His course focuses on the seven basic SI units and introduces the quantum metrology principle to recover them in the lab. In his teaching classes, he also introduced the cutting-edge researches and applications related to quantum metrology technologies in certain large scientific or engineering facilities, such as very long baseline interferometry (VLBI), Square Kilometre Array (SKA), Global Navigation Satellite System (GNSS), Laser Interferometer Gravitational-Wave Observatory (LIGO) and so on. He has also organized the lab tours in National Institute of Metrology and Beijing Institute of Radio Metrology and Measurement, which expanded the limit of Tsinghua lab resources.

- Experimental Exploration of Measurement and Control Technology & Instrument (No. 00130392)

Professor Wang is the principle lecture of this new course (32 class hours). It has been introduced to the freshman of the Mechanical Aerospace and Power Engineering (MAPE) category. Since 2016, Tsinghua University started the education and teaching reform of “enrolment and training of students in large category”. For the MAPE category, it includes the Department of Precision Instrument, Mechanical Engineering, Energy and Power Engineering, Automotive Engineering, and School of Aerospace Engineering, and contains over 10 majors. All students in this category have the same training program for their first year, except that they can select one exploration course offered by different department of the category. Consequently, this course will have a great impact on their major choice after the first year study. As the principle lecture of this course, he led the preparation of the experimental guidebook. Professor Wang directed students to complete 15 exploration experiments, which cover the MEMS sensors and application, signal's acquisition, transmission and recovery, optical measurement such as LIDAR, and so on. He encouraged students using MATLAB, C++ codes to solve the experimental problems, using Origin software to analyze experimental data and complete experimental report. In order to have students in the class sufficient exercises through the experimental report and receive high quality feedback in-time through grading, Professor Wang explored the online homework and grading systems to develop an effective approach for teaching.

- Social practice for Graduate students (No.69990041)

This is an essential 6-full-week summer course for year-two PhD students. Professor Wang took this course loading in 2015, with the assistance of one teaching assistant and one administrative assistant. Because it is largely organized and taught in different cities outside Beijing, this course requires good organization to run efficiently and smoothly. The entire organization period will be lasted over 6 months. Each year, Professor Wang selects the practice programs for students in April, organizes the two-way selection between students and enterprises in May, sends students to different practice enterprises at the end of June, conducts the mid-term inspection of the practice programs in July, and grades their practice outcomes through oral presentations and written reports in September. This course has been honored as the second prize of the Tsinghua University outstanding organization work of social practice for graduate students in 2016 and 2017.

C.2 New courses introduced at Tsinghua.

Course Title	Dates Introduced/ Taught	Enrollment	Preparation of Instructional Materials
Quantum Metrology: Principle and Application	Fall 2016	32	Responsible for preparation of all instructional materials.
Experimental Exploration of Measurement and Control Technology & Instrument	Spring 2018	15	Responsible for preparation of all instructional materials, and the experimental system.

C.3 Courses taught at Tsinghua.

Course Title	Dates Introduced/ Taught	Enrollment	Credit
Quantum Metrology: Principle and Application	Fall 2022	18	2
Experimental Exploration of Measurement and Control Technology & Instrument	Summer 2022	9	3
Quantum Metrology: Principle and Application	Fall 2021	19	2
Experimental Exploration of Measurement and Control Technology & Instrument	Summer 2021	9	3
Symposium on the history of science and technology	Spring 2021	25	1
Experimental Exploration of Measurement and Control Technology & Instrument	Spring 2021	15	2
Symposium on the history of science and technology	Fall 2020	25	1
Experimental Exploration of Measurement and Control Technology & Instrument	Fall 2020	15	2
Quantum Metrology: Principle and Application	Fall 2020	17	2
Experimental Exploration of Measurement and Control Technology & Instrument	Spring 2020	15	2

Control Technology & Instrument			
Quantum Metrology: Principle and Application	Fall 2019	22	2
Experimental Exploration of Measurement and Control Technology & Instrument	Spring 2019	15	2
Quantum Metrology: Principle and Application	Fall 2018	22	2
Social practice for Graduate students	Summer 2018	39	1
Experimental Exploration of Measurement and Control Technology & Instrument	Spring 2018	15	2
Quantum Metrology: Principle and Application	Fall 2017	31	2
Social practice for Graduate students	Summer 2017	28	1
Quantum Metrology: Principle and Application	Fall 2016	32	2
Social practice for Graduate students	Summer 2016	32	1
Social practice for Graduate students	Summer 2015	31	1

C.4 Ph.D and M.S. thesis supervised.

NAME	DEGREE	GRAD DATE	NAME OF CO-CHAIR	TITLE
Wenlin Li	PhD	2022-Present	N/A	TBD (Just enrolled)
Zhongwang Pang	PhD	2021-present	N/A	TBD (Just enrolled)
Hongfei Dai	PhD	2020-present	N/A	TBD (Just enrolled)
Guan Wang	PhD	2019-present	N/A	TBD (Just enrolled)
Yufeng Chen	PhD	2018-present	N/A	TBD (Just enrolled)
Fangmin Wang	PhD	2017-present	N/A	TBD (Just enrolled)
Hongwei Si	PhD	2015-2020	Lijun Wang	Research on Time, Frequency and Phase Synchronization Technologies over Optical Fiber Links
Xu Yuan	MS	2015-2018	N/A	Technical Research on Sub-nanosecond Time Synchronization Network and its Application
Yichen Guo	PhD	2014-present	Lijun Wang	Research on the distributed timing and time keeping system
Jingwen Dong	PhD	2013-2018	Lijun Wang	Accurate Measurement of Time Delay and Its Application in Satellite-Based Time and Frequency Synchronization
Yibo Yuan	PhD	2012-2017	Lijun Wang	The Research on Fiber-based Time and Frequency Dissemination and Synchronization Technique
Xi Zhu	PhD	2011-2016	Lijun Wang	Fiber-based Time and Frequency Synchronization Network and Application
Jing Miao	PhD	2010-2015	Lijun Wang	Time and Frequency Synchronization

				in Free Space
Yu Bai	PhD	2010-2015	Lijun Wang	Fiber-based Time and Frequency Synchronization Network and Aerospace Measurement Application
Chao Gao	PhD	2009-2014	Lijun Wang	Ultra-high Precision Synchronization of Time and Frequency with Applications

C.5 Undergraduate diploma projects directed.

- [1] Zhongwang Pang (2021) Phase sensitive vibration sensing system based on the laser interferometry
- [2] Hongfei Dai (2020) Resolution improvement using different-reference-sampling measurement method
- [3] Guan Wang (2019). Low phase noise large dynamic range laser system
- [4] Yufeng Chen (2018). Precise time difference prediction of atomic clocks based on neural network.
- [5] Xuanyu Zhu (2017). The satellite's observation and tracking using optical telescope.
- [6] Junzi Su (2016). The design of the real-time normalization function of the phase fluctuation detection system.
- [7] Hongwei Si (2015). Time delay measurement methods based on picosecond optical pulses.
- [8] Wei Ren (2015). The phase fluctuation measurement system based on quadrature mixing.
- [9] Yichen Guo (2014). The free-space frequency transfer and synchronization.
- [10] Zhaobo Qin (2013). The design of the distance measurement system based on car's headlight.
- [11] Jingwen Dong (2013). The design of the hardware system of the Allan variance analysis system.
- [12] Duxian Jin (2012). The design and finite element analysis of the Whispering-Gallery-Mode cavity.
- [13] Zhou Fang (2012). Laser ranging using the multi-frequency modulation method.
- [14] Chongxi Bao (2012). The real-time Allan Variance analysis of the frequency signal.
- [15] Yupeng Liu (2011). The finite element analysis of the ultrastable laser cavity.

C.6 Undergraduate special projects directed.

- [1] Jin Pu (2021.10-2022.12). "Acoustic monitor system based on the telecommunication fiber network".
- [2] Bohan Zhang, Haiqing Hao (2020.9-2021.12). "Design of phase sensitive vibration detection system based on optical network". It is

further supported by Beijing College Students Scientific Research and Entrepreneurial Action Plan.

- [3] Hongfei Dai, Yousi Yang, Mengxuan Zhang (201909-202009). “Realization and improvement of indoor positioning function based on UWB Technology”.
- [4] Yufeng Chen, Yuanyuan Wei, Chaonan Ji (2017.9-2018.6). “The indoor positioning system design based on UWB technique”.
- [5] Han Ma, Lingyun Zhang (2017.3-2018.4). “The spacecraft’s tracking using optical telescope”. It is further supported by National Undergraduate Innovation and Entrepreneurship Training Program.
- [6] Wensheng Yang, Yixin Ling (2016.5-2017.5). “Transfer and traceability of quantity value-Meter and Candela”. It is further supported by Beijing College Students Scientific Research and Entrepreneurial Action Plan.
- [7] Yuchen Wang (2016.5-2017.5). “The phase fluctuation monitor system designed for SKA frequency synchronization system”. It is further supported by National Undergraduate Innovation and Entrepreneurship Training Program.

D. RESEARCH

D.1 Candidate's own statement of contributions to research.

(written in the 3rd person)

Professor Bo Wang became a faculty member in the Department of Precision Instrument at Tsinghua University in 2010, and was promoted to Associate Professor in 2012. Since then, the amount of funding and grants of all projects in which Professor Wang works as PI are above CNY 18M (USD 2.7 M), and his recognized and expanding research program has focused on three major components:

(1) Precise time and frequency synchronization methods and devices.

The synchronization of time and frequency between remote locations is crucial for many important applications. Professor Wang's group supports a major effort in the development and validation of new concepts in precise time and frequency synchronization methods and devices. Recent accomplishments include the precise and continuous time and frequency synchronization at the 5×10^{-19} level between Tsinghua University and National Institute of Metrology (NIM), a series of methods and experimental demonstrations on fiber based multiple-access time and frequency ultra-stable dissemination, ultra-stable microwave frequency dissemination in free space and implications on ground-to-satellite synchronization, the time and frequency synchronization methods suitable for branching networks, highly accurate fiber transfer delay measurement methods. Under the support of national key scientific instrument and equipment development project (CNY 3.56 M), the engineering prototype of fiber based frequency dissemination device has also been developed.

(2) Clock comparison and distributed time-keeping using the time and frequency synchronization network.

Using the self-developed fiber based frequency dissemination devices, Professor Wang's group constructed the Beijing regional frequency synchronization network, which linked Tsinghua University's time-keeping clock (H-Maser) with those of NIM, Beijing Satellite Navigation Center, and Beijing Institute of Radio Metrology and Measurement via the urban telecommunication fiber network. Using this network, the real-time and continuous frequency comparisons between 5 remote H-Maser clocks of 4 different institutions have been realized. Using this powerful synchronization network, a very interesting work-Correlation Measurement of Co-Located Hydrogen Masers has been investigated. In the area of time-keeping, a longstanding question is "Does any correlation exist among co-located time-keeping clocks?" Most of the scientists believe the answer is yes, but nobody has experimentally demonstrated or quantitatively measured it directly. The measurement of clock correlation is difficult via phase comparison just within the correlated clock cluster. It is similar to that of people sitting on a bus who cannot determine that they are moving by simply looking at each other but instead must look out of the window. With the help of frequency synchronization network, the remote clocks can be introduced to the correlated clock cluster and the correlation coefficient can be quantitatively measured. Currently, a distributed time-keeping system based on the frequency synchronization network is under investigation.

(3) Optical Network Sensing

The United Nations (UN) General Council has announced that 2022 is formally designated as the UN International Year of Glass. It shows glass's essential role in human life and the prospect of further exploring its hidden functions in more and more areas. As a special form of glass, optical fiber has

profound effects on human lives, optical fiber network has become one of the largest infrastructures in the world. How to make the best use of this widespread fiber network has been the subject of intense scholarly debate. Beside the basic telecommunication function, several new chances of optical fiber network have been studied in recent years. Recently, Prof. Wang' group demonstrates that urban fiber cable can be used to detect the traffic vibrations via laser interferometry. Considering complex urban scenarios, high precision vibration localization is necessary. He proposes a novel time shifting deviation (TSDEV) method [Photonics Research; JLT], and realize ~2.5 m vibration localization accuracy. Two field tests are also carried out on the campus road and Beijing ring road, and traffic flow can be monitored in real time (JLT). The anonymous method can be a valuable complement to the user-authorized mobile phone navigation services (for example, AutoNavi), and has potential to become a city-wide infrastructure health 135 monitoring method. This work is supported by NSFC.

(4) Development of the frequency synchronization system for SKA.

Professor Wang has been deeply involved in the international large scientific facility-Square Kilometer Array (SKA). SKA requires several revolutionary technological breakthroughs, one of which is the ultra-high precision frequency synchronization for thousands of antennas aligned to form an array. Professor Wang's group proposed and demonstrated a new frequency dissemination and synchronization method which featured phase-noise compensation performed at the client site. One central transmitting module can thus be linked to multiple client sites, and future expansion to additional receiving sites will not disrupt the structure of the central transmitting station. This design has been accepted for SKA-LOW telescope on 9th October 2017 after a technical down-selection. During the research and development period, Professor Wang led his PhD students to conduct the field tests at South Africa (SKA station), and Jodrell Bank observatory of the UK (two times), respectively. Currently, Professor Wang is taking up the work package leader of frequency synchronization system for SKA-LOW, leading the Detailed Design Document preparation work and passed the critical design review of the SKA organization on 16th May 2018. Under the funding support of MOST, and collaborated with researchers from UK, Netherland, South Africa, Australia, Peking University and Beijing SUPLET company, the engineering prototype of SKA frequency synchronization device has been developed out.

D.2 Grants and contracts.

Grant Activity

1. Agency/Title of Grant: NSFC/ The phase sensitive vibration detection method based on the time and frequency synchronization fiber network
2. Duration of Funding (mm/dd/yy – mm/dd/yy): 4 years (01/01/2022-31/12/2025)
3. Total amount of award: \$100,000 (CNY 630,000)
4. Your role and amount for which you are directly responsible: PI

5. Co-investigators: N/A

Grant Activity

1. Agency/Title of Grant: China innovation Program /High precision time and frequency synchronization network

2. Duration of Funding (mm/dd/yy – mm/dd/yy): 1 years (01/11/2021-31/12/2022)

3. Total amount of award: \$630,000 (CNY 4,000,000)

4. Your role and amount for which you are directly responsible: PI

5. Co-investigators: N/A

Grant Activity

1. Agency/Title of Grant: China innovation Program /Time and frequency synchronization network

2. Duration of Funding (mm/dd/yy – mm/dd/yy): 1 years (30/06/2020-30/06/2021)

3. Total amount of award: \$333,333 (CNY 2,100,000)

4. Your role and amount for which you are directly responsible: PI

5. Co-investigators: N/A

Grant Activity

1. Agency/Title of Grant: China innovation Program /Ultra-long distance frequency dissemination

2. Duration of Funding (mm/dd/yy – mm/dd/yy): 1.5 years (01/06/2019-12/31/2020)

3. Total amount of award: \$476,190 (CNY 3,000,000)
4. Your role and amount for which you are directly responsible: PI
5. Co-investigators: N/A
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Grant Activity

1. Agency/Title of Grant: NSFC/time scale with regional remote clocks via fiber-based time and frequency dissemination
2. Duration of Funding (mm/dd/yy – mm/dd/yy): 4 years (01/01/2020-12/31/2023)
3. Total amount of award: \$103,174 (CNY 650,000)
4. Your role and amount for which you are directly responsible: PI
5. Co-investigators: N/A
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1. Agency/Title of Grant: NSFC/High precision time and frequency transfer and comparison technology
2. Duration of Funding (mm/dd/yy – mm/dd/yy): 3 years (01/01/2019-12/31/2021)
3. Total amount of award: \$672,830 (CNY 4,300,000)
4. Your role and amount for which you are directly responsible: Co-PI: \$125,177 (CNY 800,000)
5. Co-investigators: Tao Liu (PI, NTSC), Jianye Zhao (Co-PI, Peking University)
-
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Grant Activity

1. Agency/Title of Grant: Ministry of Science and Technology of China/ Development and application of the Cesium fountain primary clock

2. Duration of Funding (mm/dd/yy – mm/dd/yy): 5 years (10/2013-06/2019)
 3. Total amount of award: \$4,339,257 (CNY 27,740,000)
 4. Your role and amount for which you are directly responsible: Co-PI: \$557,042 (CNY 3,560,000)
 5. Co-investigators: Tianchu Li (Co-PI, CNY 2,880,000), Fang Fang (Co-PI, CNY 6,140,000), Desheng Lv (Co-PI, CNY 6,380,000), Aimin Zhang (Co-PI, CNY 1,490,000), Chunhao Han (Co-PI, CNY 1,490,000), RuiFeng Zheng (Co-PI, CNY 5,800,000)
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Grant Activity

1. Agency/Title of Grant: Equipment advance research project /Fiber transfer delay measurement system
 2. Duration of Funding (mm/dd/yy – mm/dd/yy): 2 years (07/2014-06/2016)
 3. Total amount of award: \$125,177 (CNY 800,000)
 4. Your role and amount for which you are directly responsible: PI
 5. Co-investigators: N/A
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Grant Activity

1. Agency/Title of Grant: The National High Technology Research and Development Program/ Research on the time and frequency synchronization network
 2. Duration of Funding (mm/dd/yy – mm/dd/yy): 3 years (07/2013-06/2016)
 3. Total amount of award: \$234,709 (CNY 1,500,000)
 4. Your role and amount for which you are directly responsible: PI
 5. Co-investigators: N/A
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Grant Activity

Agency/Title of Grant: The national satellite navigation program/ The fiber based time synchronization system

2. Duration of Funding (mm/dd/yy – mm/dd/yy): 3 years (01/2013-12/2015)

3. Total amount of award: \$375,534 (CNY 2,400,000)

4. Your role and amount for which you are directly responsible: PI

5. Co-investigators: N/A

Grant Activity

1. Agency/Title of Grant: Beijing Higher Education Young Elite Teacher Project

2. Duration of Funding (mm/dd/yy – mm/dd/yy): 3 years (10/2013-10/2015)

3. Total amount of award: \$23,471 (CNY 150,000)

4. Your role and amount for which you are directly responsible: PI

5. Co-investigators: N/A

D.3 Pending Grant Activity

E. PUBLICATIONS AND PRESENTATIONS

If multiple authors are listed, the primary contributors are designated by an asterisk.*

E.1 Refereed journal papers.

List in chronological order papers that have appeared, have been accepted or have been submitted for review. A paper will be regarded as accepted if no further action is required on the part of the author other than review of page proofs.

- [1] Yufeng Chen, Hongfei Dai, Hongwei Si, Fangmin Wang, **Bo Wang***, and Lijun Wang. Long-haul High Precision Frequency Dissemination based on Dispersion Correction. *IEEE Transactions on Instrumentation and Measurement*, DOI: 10.1109/TIM.2022.3214617, 2022 (in press).
- [2] Guan Wang, Zhongwang Pang, Fangmin Wang, Yufeng Chen, Hongfei Dai, **Bo Wang***. Urban Fiber based Laser Interferometry for Traffic Monitoring and Analysis. *Journal of Lightwave Technology*, DOI: 10.1109/JLT.2022.3209499, 2022 (in press).
- [3] Haiqing Hao, Zhongwang Pang, Guan Wang, **Bo Wang***. Indoor optical fiber eavesdropping approach and its avoidance. *Optics Express*, 30(20):36774-36782, 2022
- [4] Bohan Zhang, Wang Guan, Zhongwang Pang, **Bo Wang***. Epicenter localization using forwardtransmission laser interferometry. *Optics Expres*, 30(13): 24020-24030, 2022.
- [5] Zhongwang Pang, Guan Wang, **Bo Wang*** and Lijun Wang, Comparison between Time Shifting Deviation and Cross-correlation Methods, *Journal of Lightwave Technology*, 40 (9): 3003-3009, 2022.
- [6] Guan Wang, Zhongwang Pang, Bohan Zhang, Fangmin Wang, Yufeng Chen, Hongfei Dai, **Bo Wang*** and Lijun Wang, Time shifting deviation method enhanced laser interferometry: ultrahigh precision localizing of traffic vibration using urban fiber link, *Photonics Research*, 10 (2):433-443, 2022.
- [7] Guan Wang, Hongwei Si, Zhongwang Pang, Bohan Zhang, Haiqing Hao, and **Bo Wang***, Noise analysis of the fiber based vibration detection system, *Optics Express*, 29, 5588, 2021.
- [8] Yufeng Chen, **Bo Wang***, Lijun Wang, Keith Grainge*, Richard Oberland, Richard Whitaker, and Althea Wilkinson, Integrated dissemination system of frequency, time and data for radio astronomy, *IEEE Photonics Journal*, 13, 7100707, 2021.
- [9] Hongwei Si, **Bo Wang***, Fangmin Wang, Yufeng Chen, and Lijun Wang, Absolute phase synchronization over optical fiber, *Optics Express*, 28(4), 4603, 2020.
- [10] Y C Guo, **B Wang***, F M Wang, F F Shi, A M Zhang, X Zhu, J Yang, K M Feng, C H Han, T C Li and L J Wang, Real-time free-running time

scale with remote clocks on fiber-based frequency network, *Metrologia*, 56(4), 045003, 2019.

- [11] Hongwei Si, **Bo Wang***, Jingwen Dong, Lijun Wang, Accurate Self-Calibrated Fiber Transfer Delay Measurement, *Review of Scientific Instruments*, 89 (8), 083117, 2018.
- [12] Yichen Guo, **Bo Wang***, Hongwei Si, Zhiwu Cai, Aimin Zhang, Xi Zhu, Jun Yang, Keming Feng, Chunhao Han, Tianchu Li, Lijun Wang*, “Correlation Measurement of Co-Located Hydrogen Masers”, *Metrologia*, 55, 631 (2018).
- [13] Xi Zhu, **Bo Wang***, Yichen Guo, Yibo Yuan, Romeo Gamatham, Bruce Wallace, Keith Grainge, Lijun Wang. “Robust fiber-based frequency synchronization system immune to strong temperature fluctuation”, *Chinese Optics Letters*, 16(1), 010605 (2018).
- [14] Grainge K*, Alachkar B, Amy Shaun, Barbosa D, Bommineni M, Boven P, Braddock R, Davis J, Diwakar P, Francis V, Gabrielczyk R, Gamatham R, Garrington S, Gibbon T, Gozzard D, Gregory S, Guo Y, Gupta Y, Hammond J, Hindley D, Horn U, Hughes-Jones R, Hussey M, Lloyd S, Mammen S, Miteff S, Mohile V, Muller J, Natarajan S, Nicholls J, Oberland R, Pearson M, Rayner T, Schediwy S, Schilizzi R, Sharma S, Stobie S, Tearle M, **Wang B**, Wallace B, Wang L, Warange R, Whitaker R, Wilkinson A, Wingfield N. “Square Kilometre Array: The radio telescope of the XXI century”, *Astronomy Reports*, 61(4), 288-296 (2017).
- [15] Yibo Yuan, **Bo Wang***, Chao Gao, Lijun Wang. “Fiber-based multiple access timing signal synchronization technique”, *Chinese Physics B*, 26(4), 040601 (2017).
- [16] Xu Yuan, **Bo Wang***. “Using single wavelength light to improve the synchronization accuracy of the White Rabbit system”, *Chinese Optics Letters*, 15(10), 101202 (2017).
- [17] Yibo Yuan, **Bo Wang***, Lijun Wang. “Fiber-based joint time and frequency dissemination via star-shaped commercial telecommunication network”, *Chinese Physics B*, 26(8), 080601 (2017).
- [18] Xi Zhu, **Bo Wang***, Chao Gao, Lijun Wang. “Fiber-based multiple-access frequency synchronization via 1f–2f dissemination”, *Chinese Physics B*, 25(9), 090601 (2016).
- [19] Jingwen Dong, **Bo Wang***, Chao Gao, Lijun Wang. “Accurate and fast fiber transfer delay measurement based on phase discrimination and frequency measurement”, *Review of Scientific Instruments*, 87(9), 093102 (2016).
- [20] Jingwen Dong, **Bo Wang***, Chao Gao, Yichen Guo, Lijun Wang. “Highly accurate fiber transfer delay measurement with large dynamic range”, *Optics Express*, 24(2), 1368 (2016).

- [21] Xi Zhu, **Bo Wang**, Chao Gao, Jingwen Dong, Lijun Wang. “Application of Ultra-stable Frequency Synchronization in the Square Kilometer Array”, *Acta Metrologica Sinica*, 36(6A), 116, (2015).
- [22] Chao Gao, **Bo Wang***, Xi Zhu, Yibo Yuan, Lijun Wang*. “Dissemination stability and phase noise characteristics in a cascaded, fiber-based long-haul radio frequency dissemination network”, *Review of Scientific Instruments*, 86(9), 093111 (2015).
- [23] **Bo Wang**, Xi Zhu, Chao Gao, Yu Bai, Jingwen Dong, Lijun Wang*. “Square Kilometre Array Telescope—Precision Reference Frequency Synchronisation via 1f-2f Dissemination”, *Scientific Reports*, 5,13851 (2015).
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- [25] Jing Miao, **Bo Wang***, Yu Bai, Yibo Yuan, Chao Gao, Lijun Wang*. “Portable microwave frequency dissemination in free space and implications on ground-to-satellite synchronization”, *Review of Scientific Instruments*, 86(5), 054704 (2015).
- [26] Chao Gao, **Bo Wang***, Yu Bai, Jing Miao, Xi Zhu, Tianchu Li, Lijun Wang. “Fiber Based Time and Frequency Synchronization System”, *Science & Technology Review*, 32(34), 41-46 (2014).
- [27] Zhengbo Wang, Lu Zhao, Shiguang Wang, Jianwei Zhang, **Bo Wang**, Lijun Wang*. “COMPASS time synchronization and dissemination—Toward centimetre positioning accuracy”, *Science China-Physics, Mechanics & Astronomy*, 57(9), 1788-1804 (2014).
- [28] Jing Miao, **Bo Wang***, Chao Gao, Yu Bai, Xi Zhu, Lijun Wang*. “Ultra-stable radio frequency dissemination in free space”, *Review of Scientific Instruments* 84(10), 104703 (2013).
- [29] Yu Bai, **Bo Wang***, Xi Zhu, Chao Gao, Jing Miao, Lijun Wang. “Fiber-based multiple-access optical frequency dissemination”, *Optics Letters*, 38(17), 3333-3335 (2013).
- [30] Shiguang Wang, Jianwei Zhang*, Zhengbo Wang, **Bo Wang**, Weixin Liu, Yanying Zhao, Lijun Wang. “Frequency stabilization of a 214.5-nm ultraviolet laser”, *Chinese Optics Letters*, 11(3), 32-34 (2013).
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- [32] Jianwei Zhang, Zhengbo Wang, Shiguang Wang, Kai Miao, **Bo Wang**, Lijun Wang*. “High-resolution laser microwave double-resonance spectroscopy of hyperfine splitting of trapped Cd and Cd ions”, *Physical Review A*, 86(2), 022523 (2012).
- [33] **Bo Wang**, Chao Gao, Weiliang Chen, Jing Miao, Xi Zhu, Yu Bai, Jianwei Zhang, Yanying Feng, Tianchu Li*, Lijun Wang*. “Precise and

- Continuous Time and Frequency Synchronisation at the 5×10^{-19} Accuracy Level”, *Scientific Reports*, 2(2), 556 (2012).
- [34] **Bo Wang**, Jianwei Zhang, Chao Gao, Lijun Wang*. “Highly efficient and isotope selective photo-ionization of barium atoms using diode laser and LED light”, *Optics Express*, 19(17), 16438-164447 (2011).
- [35] **Bo Wang**, Jianwei Zhang, Ze-huang Lu, Lijun Wang. “Direct measurement of micromotion speed in a linear quadrupole trap”, *Journal of Applied Physics*, 108(1), 013108 (2010).
- [36] **Bo Wang**, Yanxu Han, Jintao Xiao, Xudong Yang, Chunhong Zhang, Hai Wang*, Min Xiao, Kunchi Peng. “Preparation and determination of spin-polarized states in multi-Zeeman-sublevel atoms”, *Physical Review A*, 75(5), 051801 (2007).
- [37] Yanxu Han, **Bo Wang**, Jie Ma, Jintao Xiao, Hai Wang*. “Measurement of the Number and Temperature of the Cold atoms EIT Medium”, *Acta Sinica Quantum Optica*, 13(1), 30-34 (2007).
- [38] **Bo Wang**, Yanxu Han, Jintao Xiao, Xudong Yang, Changde Xie, Hai Wang*, Min Xiao. “Multi-dark-state resonances in cold multi-Zeeman-sublevel atoms”, *Optics Letters*, 31(24), 3647-3649 (2006).
- [39] Shujing Li, **Bo Wang**, Xudong Yang, Yanxu Han, Hai Wang*, Min Xiao, K. C. Peng. “Controlled polarization rotation of an optical field in multi-Zeeman-sublevel atoms”, *Physical Review A*, 74(3), 033821 (2006).
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- [43] **Bo Wang**, Shujing Li, Hong Chang, Haibin Wu, Changde Xie, Hai Wang*. “Effect of one-photon detuning on light speed reduction in a three-level Λ -type atomic system”, *Acta Physica Sinica*, 54(9), 4136~4140 (2005).
- [44] **Bo Wang**, Shujing Li, Jingqin Yao, Jie Ma, Feng Peng, Gang Jiang, Hai Wang*. “Experimental observation of the linewidth narrowing of electromagnetically induced transparency resonance”, *Chinese Optics Letters*, 3(8), 486-489 (2005).

- [45] Haibin Wu, Jingqin Yao, Hong Chang, Jie Ma, **Bo Wang**, Hai Wang*. “A Simple Experiment System for Laser Cooling and Trapping $\sim(87)\text{Rb}$ Atom”, *Acta Sinica Quantum Optica*, 11(2), 79-83 (2005).
- [46] **Bo Wang**, Jingqin Yao, Haibing Wu, Yun Shen, Changde Xie, Hai Wang*. “Narrowing Linewidth and Continuously Frequency-Tuning of a Semiconductor Laser”, *Acta Sinica Quantum Optica*, 10(2), 82-86 (2004).

E.2 Refereed conference or symposium papers.

Citations should include the proceedings title, editor(s), and full page numbers or number of pages.

- [1] Bo Wang, Fangmin Wang, Guan Wang, Zhongwang Pang, Bohan Zhang. Using Fiber Network to Realize Synchronization, Timekeeping and Vibration Sensing. IEEE Summer Topicals Meeting Series (SUM), July. 2022. (Invited)
- [2] Y.C. Guo, **B. Wang***, F.M. Wang, H.W. Si, Y.N. Zuo, L.J. Wang, Beijing Time and Frequency Network and Derived Real-Time Time Scale, 2019 Joint Conference of the IEEE International Frequency Control Symposium and European Frequency and Time Forum (EFTF/IFC), Orlando, FL, USA, 14-18 April 2019.
- [3] Hongwei Si, **Bo Wang***, Jingwen Dong, Lijun Wang. “Accurate Signal Transmission Delay Measurement in Optical Fibers with Self-calibration Configuration”, 2018 IEEE International Frequency Control Symposium, Olympic Valley, California, USA, 2018.5.21-2018.5.24.
- [4] Yichen Guo, **Bo Wang***, Jingwen Dong, Hongwei Si, Lijun Wang. “Correlation Measurement of Co-Located Hydrogen Masers Using Fiber-Based Frequency Synchronization Network”, *Precise Time and Time Interval Systems and Application*, Reston, VA, USA, 2018.1.29-2018.2.1.
- [5] Yichen Guo, **Bo Wang***, Hongwei Si, Lijun Wang. “The correlation of co-located hydrogen masers”, CTFS2017, Xi’an, China, 2017.10.15-2017.10.17.
- [6] Xu Yuan, **Bo Wang***. “Using Single Wavelength Light to Improve the Synchronization Accuracy of White Rabbit System”, CTFS2017, Xi’an, China, 2017.10.15-2017.10.17.
- [7] Xu Yuan, **Bo Wang***. “A Novel Synchronization Method for WR System”, *Proceedings of 2017 Joint Conference of the European Frequency and Time Forum and IEEE International Frequency Control Symposium (EFTF/IFC 2017)*, 91-94, Besançon, France, 2017.7.9-2017.7.13.
- [8] Jingwen Dong, **Bo Wang***, Hongwei Si, Lijun Wang. “Multichannel precision time delay measurement in optical fibers”, *Proceedings of 2017 Joint Conference of the European Frequency and Time Forum and*

- IEEE International Frequency Control Symposium (EFTF/IFC 2017), 98-99, Besançon, France, 2017.7.9-2017.7.13.
- [9] Jingwen Dong, **Bo Wang***, Hongwei Si, Lijun Wang. “High Precise Time Delay Measurement in Optical Fiber”, Proceedings of China Satellite Navigation Conference (CSNC 2017), 553-561, Shanghai, China, 2017.5.23-2017.5.25.
- [10] Yichen Guo, **Bo Wang***, Yibo Yuan, Lijun Wang. “Optimized 1f-2f fiber-based frequency dissemination system for practical applications in Square Kilometre Array”, China Satellite Navigation Conference (CSNC 2017), Shanghai, China, 2017.5.23-2017.5.25.
- [11] Yichen Guo, **Bo Wang***, Hongwei Si, Jingwen Dong, Lijun Wang. “Formation of a Real-Time Time Scale with Fiber-Based Frequency Transfer Network”, Proceedings of 2017 Conference on Lasers and Electro-Optics (CLEO 2017), 1-2, San Jose, California, USA, 2017.5.14-2017.5.19.
- [12] Chao Gao, **Bo Wang***, Yibo Yuan, Xi Zhu, Lijun Wang. “The field trial of the frequency dissemination system for Square Kilometre Array radio telescope”, Proceedings of 2016 IEEE International Frequency Control Symposium (IFCS 2016), New Orleans, LA, USA, 2016.5.9-2016.5.12.
- [13] Xi Zhu, **Bo Wang***, Chao Gao, Yibo Yuan, Jingwen Dong, Lijun Wang. “Optimized 1f-2f Actively Compensated Frequency Synchronization”, 2016 European Frequency and Time Forum (EFTF 2016), Univ York, York, England, 2016.4.4-2016.4.7.
- [14] Jingwen Dong, **Bo Wang***, Chao Gao, Yichen Guo, and Lijun Wang. “Highly accurate multichannel fiber transfer delay measurement”, Proceedings of 2016 Conference on Lasers and Electro-Optics (CLEO 2016), SM3P.5, San Jose, California, USA, 2016.6.5-2016.6.10.
- [15] Yibo Yuan, **Bo Wang***, Chao Gao, Lijun Wang. “Research on Multiple-access fiber based time transfer”, CTFS, Beijing, 2015.9.15.
- [16] Jingwen Dong, **Bo Wang***, Jing Miao, Lijun Wang. “High Precise Time Delay Measurement in Optical Fiber”, China Time and Frequency Symposium (CTFS 2015), Beijing, China, 2015.9.15.
- [17] **Bo Wang***, Xi Zhu, Yu Bai, Chao Gao, Li jun Wang. “Actively and passively compensated RF frequency disseminations on branching fiber network”, Proceedings of 2015 Joint Conference of the IEEE International Frequency Control Symposium and the European Frequency and Time Forum (FCS 2015), 747-748, Denver, CO, USA, 2015.4.12-2015.4.16.
- [18] Chao Gao, **Bo Wang***, Xi Zhu, Tianchu Li, Lijun Wang. “Investigating the correlation between hydrogen-maser clocks in the same place”, Proceedings of 2015 Joint Conference of the IEEE International Frequency Control Symposium and the European Frequency and Time Forum (FCS 2015), 562-564, Denver, CO, United States, 2015.4.12-2015.4.16.

- [19] Jing Miao, **Bo Wang***, Chao Gao, Yu Bai, Xi Zhu, Lijun Wang. “Progress of ultra-stable frequency dissemination and synchronization in free space”, Proceedings of 2014 European Frequency and Time Forum (EFTF 2014), 314-316, Neuchatel, Switzerland, 2014.6.23-2014.6.26.
- [20] Chao Gao, **Bo Wang***, Xi Zhu, Jing Miao, Yu Bai, Tianchu Li, Lijun Wang. “The three corner hat measurement of three hydrogen masers in remote locations via fiber based frequency synchronization network”, Proceedings of 2014 European Frequency and Time Forum (EFTF 2014), 259-261, Neuchatel, Switzerland, 2014.6.23-2014.6.26.
- [21] Yu Bai, **Bo Wang***, Chao Gao, Weiliang Chen, Jing Miao, Xi Zhu, Lijun Wang. “Fiber-based multiple-access ultrastable radio and optical frequency dissemination”, Proceedings of 2013 Joint European Frequency and Time Forum and International Frequency Control Symposium (EFTF/IFC 2013), 1014-1017, Prague, Czech Republic, 2013.7.21-2013.7.25.
- [22] C. Gao, **B. Wang***, X. Zhu, J. Miao, Y. Bai, W.L. Chen, T. C. Li, and L. J. Wang. “The progress of Fiber Based Time and Frequency Synchronization System in Beijing Area”, China Time and Frequency Symposium (CTFS), B1, Yan’an, 2013.
- [23] Jing Miao, **Bo Wang***, Chao Gao, Yu Bai, et al. “Ultra-stable Frequency Dissemination and Synchronization”, China Time and Frequency Symposium (CTFS), B185, Yan’an, 2013.
- [24] Yu Bai, **Bo Wang***, Jing Miao, Chao Gao, Xi Zhu, Lijun Wang*. “Fiber Based Multiple-Access Optical Frequency Dissemination”, China Time and Frequency Symposium (CTFS), B15, Yan’an, 2013.
- [25] Chao Gao, **Bo Wang***, Xi Zhu, Jing Miao, Yu Bai, Tianchu Li, Lijun Wang. “Progress of the beijing regional time and frequency network”, 2013 Conference on Lasers and Electro-Optics (CLEO 2013), San Jose, California, USA, 2013.6.9-2013.6.14.
- [26] **Bo Wang***, Chao Gao, Weiliang Chen, Yu Bai, Jing Miao, Xi Zhu, Tianchu Li, Lijun Wang. “Fiber based time and frequency synchronization system”, Proceedings of China Satellite Navigation Conference (CSNC 2013), 349-356, Wuhan, China, 2013.5.13-2013.5.17.
- [27] C. Gao, **Bo Wang**, Y. Bai, J. Miao, and L.J. Wang. “The progress of indium ion optical frequency Standard”, The 5th international symposium on cold atom physics, 58, the three Gorges, 2012.6.23-2012.6.27.
- [28] **Bo Wang**, Chao Gao, Weiliang Chen, et al. “Precise time and frequency synchronization at the 5×10^{-19} level”, ISCAP-V (International Symposium on Cold Atom Physics), 57, The Three Gorges, 2012.
- [29] Jianwei Zhang*, Zhengbo Wang, Shiguang Wang, Kai Miao, **Bo Wang**, Lijun Wang. “Progress towards a microwave frequency standard based on the laser cooled $^{113}\text{Cd}^+$ ions”, Proceedings of 2012 IEEE

International Frequency Control Symposium (IFCS 2012), 105-107, Baltimore, MD, USA, 2012.5.21-2012.5.24.

- [30] **Bo Wang***, Chao Gao, Weiliang Chen, Jing Miao, Yu Bai, Tianchu Li, Lijun Wang. “Fiber-based time and frequency dissemination between THU and NIM”, Proceedings of 2012 IEEE International Frequency Control Symposium (IFCS 2012), 673-676, Baltimore, Maryland, USA, 2012.5.21-2012.5.24.
- [31] **Bo Wang***, Chao Gao, Weiliang Chen, Jianwei Zhang, Yanying Feng, Tianchu Li, Lijun Wang. “A 10-18/day fiber-based RF frequency dissemination chain”, Proceedings of Science and Innovations, CLEO_SI 2012, CTh4A.3, San Jose, California, USA, 2012.5.6-2012.5.11.
- [32] **Bo Wang**, Weixin Liu, Chao Gao, Yu Bai, Jing Miao, Lijun Wang. “CPT optical clock based on the barium crystal”, NCOQE2011, 355, Beijing, 2011.3.18-2011.3.19.
- [33] **Bo Wang**, Chao Gao, Weiliang Chen, et al. “High stability dissemination and comparison of atomic signals”, China Time and Frequency Symposium (China Time and Frequency Symposium), 381, Beijing, 2011.
- [34] Hai Wang*, **Bo Wang**, Shuijing Li, Xudong Yang, Yanxu Han. “Study on EIT and its dispersion effect in multi-level Atoms”, National Quantum Optics Conference 2006, Nanchang, China, 2006.8.19-2006.8.22.
- [35] **Bo Wang**. “Enhanced Two-Photon Absorption via Quantum Interference in a N-type Atomic System”, Doctoral Forum of China in Physics, GUCAS, Beijing, China, 2006.7.
- [36] **Bo Wang**, Jingqin Yao, Haibin Wu, Shujing Li, Cahngde Xie, Hai Wang. “Light speed reduction and storage in Λ -type Three-level Atom System”, National Quantum Optics Conference 2004, Dujiangyan, China, 2004.8.8-2004.8.10.

E.3 Invited publications and conference/symposium presentations.

- [1] Using Fiber Network to Realize Synchronization, Timekeeping and Vibration Sensing. IEEE Summer Topicals Meeting Series (SUM), July. 2022.
- [2] Fiber based Time-Frequency synchronization and application, Frontier academic forum of Department of electronics, Peking University, Issue 18, Beijing, Nov. 12, 2021.
- [3] Correlation Measurement of Co-Located Hydrogen Masers, the 7th Tsinghua-Yonsei Joint workshop, Yonsei University, Seoul, South Korea, Jul. 2018.
- [4] High-Precision measurement of signal transmission delay in optical fiber, The 6th Tsinghua-Yonsei Joint workshop, Tsinghua University, Beijing, China, Feb. 2017

- [5] Precise time and frequency synchronization and its application in the international large-scale scientific facility-SKA, The 5th Tsinghua-Yonsei Joint workshop, Yonsei University, Seoul, South Korea, Apr. 2016
- [6] STFR-THU Astronomical Verification at Jodrell Bank Observatory, The SKA-SaDT consortium meeting, University of Western Australia, Perth, Australia, Jul. 2016.
- [7] Fiber based ultra-stable frequency dissemination and its applications. 2015 EMN Optoelectronics Meeting (Energy Material Nanotechnology), Beijing, China, Apr. 2015.
- [8] Time and frequency synchronization and related applications, The 4th National Forum on Young Scientists in Atomic Molecule Physics, Shanxi University, Taiyuan, Shanxi, China, Oct. 2014.
- [9] SAT-STFR functional design, The SKA-SaDT consortium meeting, University of Manchester, Manchester, UK, Jun. 2014.

E.4 Un-refereed SKA related publications

Some of Professor Wang's work were preparing the technical design for the SKA synchronization and timing system. In support of this work he was an author on the following document sets provided for the SKA Critical Design Review.

- [1] **Bo Wang**, Yichen Guo, Chao Gao, TSINGHUA SOUTH AFRICAN SKA OVERHEAD FIBRE FIELD TRIAL REPORT, Document Number: SKA-TEL-SADT-0000169-SADT.SAT.STFR, 2018.07.08. (32 pages)
- [2] **Bo Wang**, STFR.FRQ.THU AVAILABILITY ANALYSIS DOCUMENT, Document Number: SKA-TEL-SADT-0000627_REP, 2018.02.28. (9 pages)
- [3] **Bo Wang**, Yichen Guo, STFR.FRQ.THU EMI TEST REPORT, Document Number: SKA-TEL-SADT-0000628_REP, 2018.02.28. (23 pages)
- [4] **Bo Wang**, STFR.FRQ.THU 4 GHz+ SYNTHESIZER TEST REPORT, Document Number: SKA-TEL-SADT-0000629_REP, 2018.02.28. (14 pages)
- [5] **Bo Wang**, STFR.FRQ.THU COHERENCE LOSS TEST REPORT, Document Number: SKA-TEL-SADT-0000630_REP, 2018.02.28. (20 pages)
- [6] **Bo Wang**, STFR.FRQ.THU VARIANCES IN OPERATIONAL CONDITIONS TEST REPORT, Document Number: SKA-TEL-SADT-0000631_REP, 2018.02.28. (45 pages)
- [7] **Bo Wang**, John Davis, SAT.STFR.FRQ (THU) TO SAT.CLOCKS (LOW) INTERNAL INTERFACE DOCUMENT, Document Number: SKA-TEL-SADT-0000436_ICD, 2018.02.26. (17 pages)

- [8] **Bo Wang**, Yichen Guo, SAT.STFR.FRQ (THU) DETAIL DESIGN DOCUMENT, Document Number: SKA-TEL-SADT-0000360, 2018.02.26. (56 pages)
- [9] Jaco Muller, Shaun Amy, **Bo Wang**, SADT SAT.STFR.FRQ (THU) TO NSDN (LOW) INTERFACE CONTROL DOCUMENT, Document Number: SKA-TEL-SADT-0000448_ICD, 2018.02.22. (21 pages)
- [10] **Bo Wang**, Yichen Guo, Chao Gao, TSINGHUA TESTS RAPID TEMPERATURE FLUCTUATION MITIGATION, Document Number: SKA-TEL-SADT-0000170-SADT.SAT.STFR, 2016.05.20. (13 pages)

F. ENGAGEMENT/TECHNOLOGY TRANSFER (if applicable)

- F.1 Candidate's own statement of contributions to technology transfer.
One page maximum. (written in the 3rd person)

Professor Wang has 7 Chinese patents issued and 3 pending. As the co-inventor, the patents (F.2[1], F.2[3], F.2[4], F.2[5], F.2[6], F.2[7]) have been licensed to Beijing General Testing Technology (BGTT) Inc. The translation of these 6 patents together with 2 other patents on gravity meter (patented by his colleagues) has been valued at 20.116 million CNY, and accounting for 40% shares of the BGTT Inc. Professor Wang also collaborated with the Beijing SUPLET company on the development of fiber based frequency synchronization instrument, especially the special design for SKA. Currently, they are preparing to supply SKA before 2020. As a full member of SKA-SaDT consortium, he has fully complied with the terms of SKA IP policy, contributing and sharing the time and frequency synchronization technologies with SKA colleagues.

- F.2 Chinese patents awarded.

- [1] Bo Wang, Guan Wang, Zhongwang Pang, A time delay estimation method and system based on the time shifting deviation method
- [2] **Bo Wang**, Jingwen Dong, Chao Gao, Yu Bai, Lijun Wang, A phase stabilized signal transfer method and system based on frequency synchronization, ZL201410190927.6. (Licensed)
- [3] **Bo Wang**, Jingwen Dong, A method and system for transfer delay and transfer distance measurement, ZL201610556896.0. (Licensed)
- [4] Lijun Wang, **Bo Wang**, Chao Gao, Yu Bai, Jingwen Dong, Xi Zhu, Compensation system rear-mounted frequency transmission system and method, ZL201410141670.5 (Licensed)
- [5] Lijun Wang, **Bo Wang**, Yu Bai, Chao Gao, Jing Miao, Xi Zhu, A microwave ranging and time synchronization method and system based on frequency synchronization, ZL201310683870.9. (Licensed)
- [6] Lijun Wang, **Bo Wang**, Jing Miao, Yu Bai, Chao Gao, Xi Zhu, A signal transfer system in free space based on phase compensation, ZL201310467522.8. (Licensed)
- [7] Lijun Wang, **Bo Wang**, Yu Bai, Chao Gao, A passive microwave frequency transfer method and system, ZL201310449436.4. (Licensed)
- [8] Lijun Wang, **Bo Wang**, Chao Gao, Jing Miao, The receiving method and receiving system of atomic frequency signal, ZL201110270288.0. (Licensed)
- [9] Lijun Wang, Tianchu Li, **Bo Wang**, Chao Gao, The distribution method and distribution system of atomic frequency signal, ZL201110186493.9. (Licensed)

- [10] Lijun Wang, **Bo Wang**, Jingwen Dong, Yu Bai, Chao Gao, A method and device to improve the oscillator stability, ZL201410314762.9. (Licensed)
- [11] Lijun Wang, Jingwen Dong, Yu Bai, **Bo Wang**, Shiguang Wang, Two way time and frequency transfer method for satellite based on real-time dual carrier phase compensation, ZL201710430456.5 (Licensed)

F.3 Chinese patents submitted.

- [1] **Bo Wang**, Hongwei Si, Yufeng Chen, A dispersion compensation method, device, and system used for long distance frequency dissemination, CN202110051021.6
- [2] **Bo Wang**, Xu Yuan, An UWB indoor positioning system based on highly precise time synchronization technique, CN201710825058.3

G. SERVICE

- G.1 Candidate's own statement of contributions to service.
One or two paragraphs maximum. (written in the 3rd person)

Professor Wang is active in making contributions to department committees, professional journals, and international organization. From 2015-2019, professor Wang has served as the Coordinator of the Graduate Student Affairs of Department of Precision Instrument (DPI), to oversee ~400 graduate students' daily activity. From 2020, the served as the tutor of Weiyang college of Tsinghua University. This spring, as a member of preparatory committee for the regular assessment of the degree authorization points, which was required by the Ministry of Education in every 5 years, he prepared the self-assessment reports of the Doctor and Master Degree authorization points of Instrument Science and Technology. Currently he is serving as the vice director of the institute of Instrumental Science and Technology, and the Key Laboratory of Photonic Measurement and Control Technology of Ministry of Education at Tsinghua University, which has nearly twenty professors in the directions of measurement and control technology. Professor Wang also contributed to Tsinghua Admissions Office by participating in recruiting high-school top students and was honored as a "Tsinghua University Outstanding Fresh Admission Officer" in 2015. Co-leading a taskforce team, Professor Wang successfully initiated and organized the 1st and 2nd summer camp of the DPI, which aimed to attract top undergraduate students from other Chinese Universities to apply for graduate studies in DPI. He is now serving as the reviewer of IEEE and OPTICA journals. He is also serving as a member of the expert panel of China National Time and Frequency Network System. Professor Wang has been the full member of SKA-SaDT consortium, and the work package leader of frequency synchronization system for SKA-LOW.

- G.2 Major committee assignments in the Department, School, and/or University. Committee, date member or chair (in chronological order).

- [1] Vice director, Institute of Instrumental Science and Technology, Tsinghua University, 2020-present
- [2] Vice director, Key Laboratory of Photonic Measurement and Control Technology of Ministry of Education, Tsinghua University, 2018-present
- [3] SKA Consultant Leads committee, 2018-present
- [4] Tsinghua University Admission Officer responsible for high schools at Jinzhong area, Shanxi Province, 2015-present
- [5] Graduate Student Affairs of Department of Precision Instrument, Coordinator, 2015-2019

G.3 Service to government or professional organization.

Type of service, dates (in chronological order).

- [1] Full member of SKA-SaDT consortium
- [2] Work package leader of the frequency synchronization system for SKA-LOW
- [3] SKA Consultant Leads committee member
- [4] Reviewer for International Journals: Optics Express, Optics Letters, Applied Optics, Applied Physics Letters, Journal of the Optical Society of America B, Chinese Optics Letters, IEEE Journals, etc.
- [5] Member of the expert panel of China National Time and Frequency Network System.
- [6] Member of the Secretary of China's SKA Comprehensive Advisory Report

H. OTHER

H.1 Collaborative activities with other faculty and institutions.

- [1] Collaboration with Professor Keith Grainger (the University of Manchester) on SKA signal and data transfer
- [2] Collaboration with Professor Tianchu Li, Professor Fang Fang, Professor Aimin Zhang (National Institute of Metrology), Professor Desheng Lv (Shanghai Institute of Optics and Fine Mechanics), Professor Chunhao Han (Beijing Satellite Navigation Center) on development and application of the Cesium fountain primary clock
- [3] Collaboration with Professor Sascha Schediwy (University of Western Australia) on the SKA synchronization of time and frequency reference
- [4] Collaboration with Professor Tim Gibbon (Nelson Mandela University, South Africa) on the SKA synchronization and timing
- [5] Collaboration with Dr. Paul Boven (ASTRON, Netherland) on the SKA synchronization and timing
- [6] Collaboration with Professor Yashwant Gupta (NCRA, India) on the SKA signal and data transfer
- [7] Collaboration with Professor Jianye Zhao (Peking University) on time and frequency synchronization
- [8] Collaboration with Professor Tao Liu (National Time Service Center) on ultra-long distance frequency transfer

H.2 Other relevant information.

NA