联合汉语和**GRAVWAVE®** 重心波浪提出的项目

(Joint Chinese & GRAVWAVE® High-Frequency
Gravitational Wave Project)

高频**引力波**

(High-Frequency **Gravitational Waves)**

2006

高频遗迹引力波探测器的研制

(Development of a High-Frequency Relic Gravitational Wave (HFRGW) Detector)

探测器的实验室检验和高频遗迹引力波的测量

(Laboratory Test of the Detector and Measurement of HFRGWs)

高频引力波源和探测器的研制

(Development of a High-Frequency Gravitational Wave (HFGW) Generator and Detector)

高频引力波源和探测器的实验室试验

(Laboratory Test of the HFGW Generator and Detector)

高频引力波技术的实际应用

(Practical Application of HFGW Technology)

项目时间表
(PROJECT TIMETABLE)

5年、10年和20年期间的规划
(THE FIVE, TEN AND TWENTY YEARS PROJECTIONS:)

●5年（2010）：

1．在GHz频段对振幅为$h=10^{-30}-10^{-31}$的高频遗迹引力波的成功探测，包括探测器的必要的精制和改进，以提高其性能。下一步的计划包括探测灵敏度、频带、结构甚至探测方式上的改进。

2．完成高频引力波的实验室产生和探测，给出高频引力波产生和探测的概念上的检验，借助于高频引力波获得相关的科学和技术知识。

(● Five Years (2010):

1. Successful construction of high-frequency relic gravitational waves (HFRGWs) ($h=10^{-30}-10^{-31}$) in the GHz band including necessary refinements and modifications of the detector in order to improve performance. Plan for the next step, including further improvement of the sensitivity, frequency band, structure and even detection method.

2. Laboratory generation and detection of HFGWs accomplished--a proof-of-concept test for HFGW generation and detection--and gaining familiarity with the science and art associated with HFGWs.)

● 10年 (2015):

对全球通讯和成像进行实验。研制全球无绳通讯系统。开展对全球勘测和勘查系统的实验。并研究通过海洋、建筑物内部的成像技术和医疗全身扫描的成像技术，以及引力波和核科学的交叉课题。

(● Ten Years (2015):

Global communications and imaging successfully tested. Wireless global communications system deployed. Global survey and reconnaissance system tested and through-ocean, building-interior and medical full-body-scan imaging as well as GW-nuclear projects under development.)

● 20年 (2025):

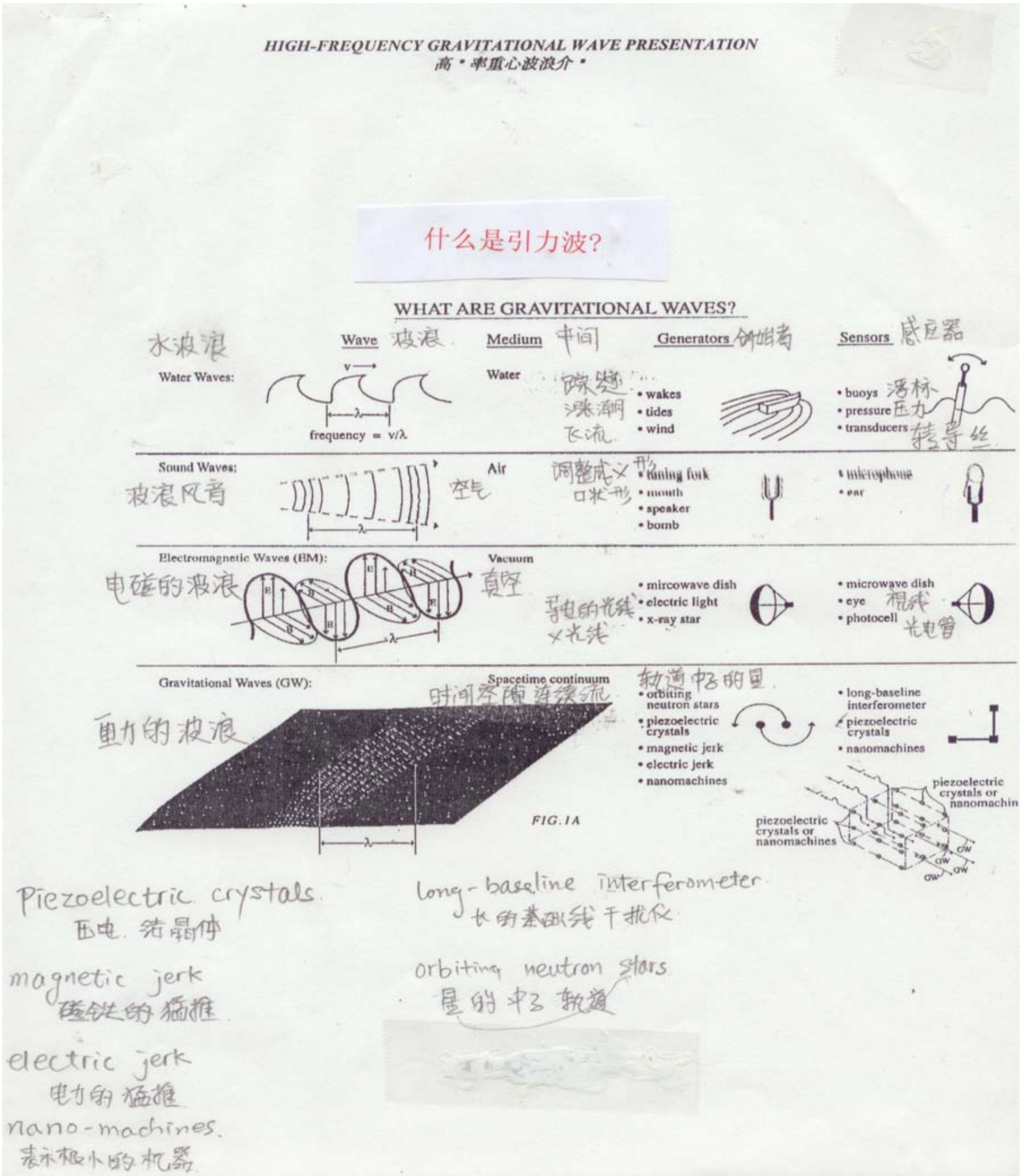
研究全球勘测和勘查系统，通过海洋、建筑物内部的成像技术和医疗全身扫描的成像的课题并使之可供使用。进行高频引力波推进实验。对远距离的高频引力波云层聚结系统进行研究。对高频引力波的质量穿击束和放射性废料游离核能的检测展开试验。

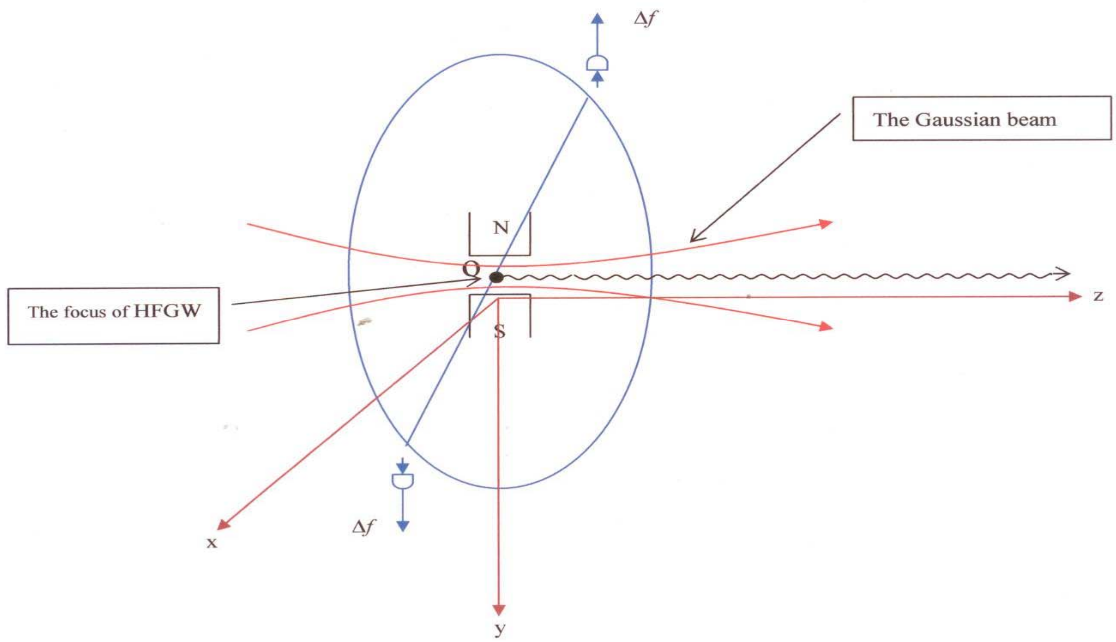
(● Twenty years (2025):

Global survey and reconnaissance system and through-ocean, building-interior, medical full-body-scan imaging projects deployed and operational. Successful test of HFGW-propulsion system. Remote HFGW cloud-coalescence system deployed. HFGW mass-disrupter-beam and radioactive-waste-free nuclear energy systems successfully tested.)

项目背景

(BACKGROUND OF PROJECT)





重庆大学高频引力波探测器的原理图

(Schematic of the Chongqing University HFGW Detector)

中国的途径是期望在历史上成功的探测高频遗迹引力波，并着手进行去产生和探测非常微弱的高频引力辐射。但上述引力辐射不足于实际的应用，包括诸如全球和地区的通讯或者移动大质量的物体，以及在核物理和其它物理学科中的应用。然而它将给出概念上的一个非常重要的证据。

(The Chinese Approach will build upon the historic success of detection of high-frequency relic gravitational waves and proceed to generate and detect a very small amount of high-frequency gravitational radiation – not enough for practical operational applications such as global or local communications, or moving large massive objects, or nuclear or other Physics; but a very important proof of concept.)

高频引力辐射将可能是对电磁辐射革命性的变革，它的应用和科学技术上的价值将可能超过电磁波。

(High-frequency gravitational radiation may be a revolutionary alternative to electromagnetic radiation and may surpass electromagnetic radiation in its applicability and value to science and Technology.)

第一阶段

(PHASE 1)

前期工作的分析

(Precursor Component Analyses)

●
完成和试验一个高频引力波的探测系统，该系统由分形膜和一个通过静态磁场 (~3T-5T)的高斯束所组成。这一探测系统将由重庆大学和相关的科研院所合作研制。

(• Procure and test a detecting system of HFGWs, the system consists of fractal membranes and a Gaussian beam passing through a static magnetic field (～3T to 15T). Such detecting system is developed cooperatively by the Chongqing University and relative institutes.)

●

将建造的中国探测器的目标是精质暴胀宇宙模型和其它弦宇宙模型中所预期的高频遗迹引力波。这种探测器将用于探测由上述高频遗迹引力波在其中所产生的扰动光子流（对上述探测器的分析和设计见Li和Baker 2006年论文的预印本）。

(• The Chinese detector for the high-frequency relic GWs (HFRGWs) in quintessential inflationary models (QIM) and some string cosmology scenarios will be fabricated in which the perturbative photon fluxes (PPFs) generated by such detector will be measured. (Utilizing the analyses and design for such a detector published in Li and Baker 2006.))

●

对4.9GHz的高频引力波探测器的实际灵敏度进行分析和研究，该引力波可望由磁控管激励的多层压电声学共振器产生。

(● Characterize the actual sensitivity of the detector to the 4.9 GHz HFGW expected to be generated by the Magnetron-energized piezoelectric FBARs.)

●

探测器的高强度高斯束的频率必须与高频引力波的频率，即波源中磁控管的频率谐振；探测器的焦点须重合于高频引力波波源的焦斑；本项目将研究完成这一目标的方法。

(● The frequency of the high-intensity Gaussian beam of the detector must be resonated with the frequency of the HFGW – generator’s Magnetrons and the detector’s focus coincident with the HFGW generator’s focal spot and the approach to accomplishing this will be investigated.)

●

确定和测试一种方法，以激励大量的磁控管在相同的频率并锁定在相同位相的条件下运行。

(● Determine and test a method for energizing a large number of Magnetrons at the same frequency and locked at the same phase.)

●

采用上海制备的硅晶体，测试几种直径4英寸或者更大的多层压电声学共振器极板，在每一个这样的极板上，可以很容易地聚集6000个以上的多层压电声学共振器。

(● Procure from silicon fabrication foundries in Shanghai and test several 4″ diameter (or larger) FBAR wafers (6000 or more FBARs may easily be fabricated on one wafer).)

●

建立起空间尺度r大小的对所产生的引力波波长λ_{GW}和四极矩辐射公式的精度的影响的解析关系。

(● Analytically establish the influence of the size of r relative to λ_{GW} on the generation of GWs and the accuracy of the quadrupole equation.)

第二阶段

(PHASE 2)

设备总装

(Apparatus Assembly)

● 实现两个或多个磁控管的锁相或同步。

(● Prove the phase lock or synchronization of two or more Magnetrons)

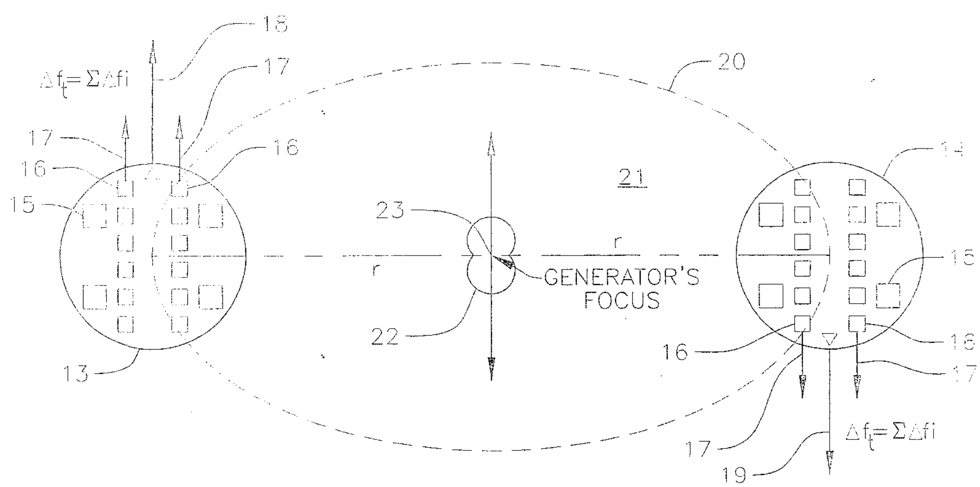
● 建立由磁控管激励的两个或系列组合的声学共振器系统。

(● Fabricate two or more banks of FBARs energized by Magnetrons)

●

建成样机，它包含由磁控管激励的两组声学共振器。该样机可模拟稳定的双星系统或者稳定转动的杆。上述系统的离心力则可以由声学共振器中的瞬时冲击力等效地替代（相关的分析和设计可见论文，Baker, Woods and Li 2006）。

(● Construct a prototype, as shown below, having two clusters of FBARs energized by Magnetrons that emulates a double-star system or a rotating rod, but stationary. The centrifugal-force replaced by the FBAR jerk. (Utilizing the analyses and design for such an apparatus published in Baker, Woods and Li 2006.))



第三阶段

(PHASE 3)

高频引力波实验

(The HFGW Tests)

- 高频遗迹引力波的振幅或功率流的探测

(●　Measurement of the HFRGWs amplitude or power flux.)

●
精质暴胀宇宙模型（QIM）和某些弦宇宙模型（SCS）的检验

(●　Determination of quintessential inflationary models (QIM) or some string cosmology scenarios (SCS).)

- 实验室产生的高频引力波的振幅和功率流的探测。

(●　Measurement of the laboratory generated HFGWs amplitude or power flux.)

- 高频引力波的极化矢量的探测。

(●　Measurement of the HFGW polarization.)

●
检测引力波源和探测器之间的不同材料对上述各参量的影响。

(●　Determination of the influence of different material (between generator and detector) on the aforementioned quantities.)

● 利用灵敏的加速度计测量可能的引力场的变化。

(●　Measurement of the possible gravitational-field modification utilizing sensitive accelerometers.)

● 评估实验室引力波产生和探测装置的性能，提出改进建议。

(●　Assess the effectiveness of the laboratory generator/detector apparatus and suggest improvements and/or refinements.)

总结

(SUMMARY)

- 这一国际水平项目的参加者包括：

李芳昱教授；中国，重庆大学

罗伯特. 贝克博士，美国，**GRAVWAV®LLC**。

(● World-class level of project participants including Professor Fangyu Li, Chongqing University, China, and Dr. Robert M. L. Baker, Jr., GRAVWAVE®LLC, USA.)

●

提升对高频引力波应用前景的理解，包括在通讯、引力推进、成像、物理学和天文学等领域可能的应用性和前瞻性研究

(● Precursor to better understanding HFGW applications to requirements in the areas of communications, propulsion, imaging, Physics and Astronomy.)

●

采用成熟的技术（这里没有不成熟的理论和未被证实的理论，例如，采用了熟知的爱因斯坦四极矩公式）和新颖的物理思想，成熟或最新的技术，国际水平的科学家和工程师，以及分阶段的实施计划可以有效地降低风险。

(● Use of proven technologies (absolutely no new or unproven theories e.g., use of Einstein's quadrupole formalism),brand new ideas, off-the-shelf or state-of-the-art components, world-class scientists and engineers, and a phased approach will reduce risk.)

正如马可尼没有预期到他的电磁实验能够用于微波炉、电视机和雷达一样，我们所预期的高频引力波实验的未来应用也可能具有广阔的前景。

(“… Marconi didn’t envision the application of his EM experiment to, for example, microwave ovens, television or radar – so there may be yet to be envisioned applications of the proposed GW experiment.”)

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参与研究单位：

(INSTITUTIONAL SUPPORT :)

中国　重庆大学
(Chongqing University,)

成都微波实验室(CML)
(Chengdu Microwave Laboratory (CML))

香港科技大学
(Hong Kong University of Science and Technology)

美国奥克兰引力物理研究所
(GRAVWAVE®LLC, and)

美国　传输科学公司

(Transportation Sciences Corporation, California, USA.)

什么国家将是一查出重心波浪?

(What country will be the first to detect Gravitational Waves?)

中国
(China)

为什么:
(Why:)

(1)那里存在至少三个低频率重心波浪**(LFGW)**侦查项目**(40 赫兹对2000Hz)** 或完整和操作或近操作: **Laser** 干涉仪重心观测所或**LIGO** 在美国和**GEO600** 和处女座**LFGW**探测器在欧洲。所有三他们有背景噪声的问题**,** 哪些他们运作**,** 并且缺乏把握何时**(**甚至如果**)**一次**LFGW**事件在他们的频率范围将发生足够近和足够强有力被查出。无这些项目可能确切地预言何时他们将是成功的。

(1) There exist at least three Low-Frequency Gravitational Wave (LFGW) detection projects (40 Hz to 2000Hz) either completed and operational or near operational: the Laser Interferometer Gravitational Observatory or LIGO in the United States and the GEO600 and Virgo LFGW detectors in Europe. All three of them have the problem of background noise, which they are working on, and the lack of certainty of when (or even if) a LFGW event in their frequency range will occur near enough and powerful enough to be detected. None of these projects can predict exactly when they will be successful.

(2)由于这不确定性计划被做为基于空间的**(**较不喧闹的环境**) Laser** 干涉仪空间天线或莉萨有一个更低的频率范围**< 40** 赫兹和一次好机会为**LFGW**侦查。**LIGO**项目已经花费大约半每十亿美元美国并且莉萨一定将花费更多。
最乐观的估计何时莉萨可使用是**2015** 年。

(2) Because of this uncertainty plans are being made for a space-based (less noisy environment) Laser Interferometer Space Antenna or LISA having a much lower frequency range < 40 Hz and a much better chance for LFGW detection. The LIGO Project has cost about half a billion dollars US already and LISA will certainly cost more. The most optimistic estimate of when LISA will be operational is 2015.

(3)那里退出至少三个高频率重心波浪(HFGW)项目(千兆赫频率)以原型或被建立或计划:被结合的高温superconductor分庭(INFN热那亚,意大利), 微波圈(伯明翰大学,英国)和半透明的射线分离机(介入一条高斯微波射线和一个静态磁场)重庆联结系统,中国。显然预言是最敏感和最唯一一个有能力在实际侦查上是中国探测器。这台探测器根据根本Gertsenshtein主要和被预言,有巨大把握,是能查出遗物HFGWs,象微波遗物背景,为人所知存在在已知的高度这里在地球上。它是只必要制造,测试,并且投入这台探测器入操作在以后五年使中国是一查出重心波浪!

(3) There exit at least three High-Frequency Gravitational Wave (HFGW) projects (GHz frequencies) with prototypes either built or planned: the coupled high-temperature superconductor chambers (INFN Genoa, Italy), the microwave loop (Birmingham University, England) and the coupling-system of semitransparent beam-splitters (involving a Gaussian microwave beam and a static magnetic field) Chongqing, China. Predicted to be by far the most sensitive and the only one capable of actual detection is the Chinese detector. This detector is based upon the fundamental Gertsenshtein principal and is predicted, with great certainty, to be capable of detecting relic HFGWs that, like the microwave relic background, is known to exist at known amplitudes here on Earth. **It is only necessary to fabricate, test, and put this detector into operation in the next five years for China to be the first to detect Gravitational Waves!**

中国HFGW探测器和发电器将有实际应用譬如对航空航天和空间物理吗?

(Will the Chinese HFGW detector and generator have practical applications such as to Aerospace and Space Physics?)

是!

(Yes!)

为什么:

(Why:)

(1)在空间技术应用国际论坛(STAIF),由物理美国学院主办(和出版在同事评审以后在他们的行动)几个技术文章被提出了关于一个基于空间的HFGW世代和检测系统运用中国探测器。这样系统会生产强有力的HFGWs和会被运用在空间技术和空间物理。

(1) At the Space Technology Applications International Forum (STAIF), sponsored by the *American Institute of Physics* (and published after peer review in their Proceedings) several technical papers have been presented concerning a space-based HFGW generation and detection system utilizing the Chinese detector. Such a system would produce powerful HFGWs and be utilized in space technology and Space Physics.

(2) HFGWs可能运载宽频通信没有对光纤的需要,微波和卫星中转,等; LFGWs 不能。 HFGWs,根据著名Landau和Lifshitz,能影响引力场(一种新空间推进力手段); LFGWs不能。HFGWs有X光芒象想象诺言通过所有物质事(直接地通过海洋和地球); LFGWs 不。 HFGWs 可能被集中为了影响问题在核水平; LFGWs 不能。 HFGWs 是浩大地优越在应用与LFGWs比较。

(2) HFGWs can carry broadband communications without the need for fiber optic cable, microwave and satellite relays, etc.; LFGWs cannot. HFGWs, according to the famous Landau and Lifshitz, can affect the gravitational field (a new space propulsion means); LFGWs cannot. HFGWs have the promise of X-ray-like imaging through all material things (directly through the oceans and the Earth); LFGWs do not. HFGWs can be concentrated in order to affect matter at the nuclear level; LFGWs cannot. HFGWs are vastly superior in application as compared with LFGWs.

(3) 总之,高频率重心波浪(HFGWs)有革命实际应用诺言对科学, 技术, 并且商务。 中国可能适合先驱在这次epoch-making 事件: 一引起和查出重心波浪在地球!

(3) In general, High-Frequency Gravitational Waves (HFGWs) have the promise of **revolutionary** practical applications to science, technology, and commerce. **China can become the pioneer in this epoch-making event: the first to generate and detect Gravitational Waves on Earth!**

简历
(RESUMES)

Fangyu 李

Dr 。 李出生在10月28 日, 1943 年。他是一名学生在物理的部门在西北师范大学, 中国从1961 年到1965 年。 从1978 年到1990 年, 他是讲师, 副教授在物理的部门在重庆大学, 中国和从1990 年到1991 年他是一位参观的科学家在莫斯科大学Sternberg 状态天文学学院的重心实验室在俄国。 Dr 。 李是副教授, 物理的部门, 重庆大学from1991 到1994 年, 被任命了大学的物理部门的经理从1996 年到1998 年, 并且被任命了科学学院的教务长在重庆大学在期间1998

年到**2000** 年。 从**1994** 年迄今，他是物理教授在大学。 **Dr** 。李是中国物理社会的委员会的成员，
中国重心和相对天体物理学的社会的委员会的成员，
并且世界实验室的成员。
他的当前研究兴趣是总之相对和万有引力，
重心波浪和重心辐射的理论， 重心波浪的互作用以电磁场，
并且古典和量子电动力学。 **Dr** 。李发表了超过五十篇论文关于重心波浪在国际上被认可的学报里。

(*Fangyu Li*

Dr. Li was born on October 28, 1943. He was a student in the Department of Physics at *Northwestern Normal University*, China from 1961 to 1965. From 1978 to 1990, he was a Lecturer, Associate Professor in the Department of Physics at *Chongqing University*, China and from 1990 to 1991 he was a Visiting Scientist at the Gravitational Laboratory of the *Sternberg State Astronomical Institute* of the *Moscow University* in Russia and was an associate of the Head of the *Gravitational Department*, Valentine Rudenko. Dr. Li was an Associate Professor, Department of Physics, *Chongqing University* from1991 to 1994, was appointed Head of the Physics Department of the University from 1996 to 1998, and was appointed Dean of the College of Science at *Chongqing University* during the period 1998 to 2000. From 1994 to date, he has been a Professor of Physics at the University. Dr. Li is a member of the Council of the *Chinese Physics Society*, member of the Council of the *Chinese Gravitational and Relativity Astrophysical Society*, and a member of the *World Laboratory*. His present research interests are in general relativity and gravitation, theories of gravitational waves and gravitational radiation, interaction of gravitational waves with electromagnetic fields, and classical and quantum electrodynamics. Dr. Li has published more than fifty papers concerning gravitational waves in internationally recognized scientific journals.)

罗伯特M 。 L 。 贝克Jr.,

Dr贝克赢得了学士的物理学学位在加州大学洛杉矶分校以最高的荣誉(summa 附带laude - 首先在他的类)被选举了对希腊语的第二十一个字母Beta Kappa, 赢得了大师的物理学学位和酸碱度。D 。在设计在加州大学洛杉矶分校。 Dr 。贝克是在部门天文在加州大学洛杉矶分校从1959 年到1963 年和部门工程学和应用科学的才干在加州大学洛杉矶分校从1963 年到1971 作为一名讲师和助理教授。 他是Lockheed 的Astrodynamics 研究中心的头在贝耳空气里, 加利福尼亚和在1964 加入了计算机科学公司作为同事经理为数学分析。 1980 年他被选举了西海岸大学的总统, 一所被检定的大学为成人学习者现在操作在美国事业学院恩惠外在洛杉矶。 在退休从在1997 的西海岸大学以后作为工程学总统和教授, Dr 。贝克成为了资深顾问为运输科学公司和GRAVWAVE. LLC 。他赢取了加州大学洛杉矶分校物理奖, 是Dirk Brouwer 褒奖的接收者为卓著的贡献在astrodynamics 和轨道技工, 是美国协会的家伙为科学的推进和是年初级商会的卓著的人的接收者褒奖在1965 出席对他由Ronald Reagan 。 Dr 。2003 年贝克是第一国际重心波浪会议的副主席人在MITRE Corporation, 尊守的重庆教授大学, 中国2004 年, 并且是几本课本的作者和一百个公司报告, 讨论会纸, 并且期刊文章在astrodynamics 区域和神圣技工包括介绍Astrodynamics (1960) 与Maud W 。 Makemson 和Astrodynamics: 应用和先进的Topics (1969) 。 Dr 。 贝克感兴趣对引力场动力学从50 年代和重心挥动研究从60

年代初期并且举行五个专利在区域重心挥动世代。 也请看见: 万维网。**drrobertbaker 。com 。**

(***Robert M. L. Baker Jr.,***

Dr. Baker earned a bachelor's degree in Physics at UCLA with highest honors (*summa cum laude* – first in his class) was elected to *Phi Beta Kappa*, earned a master's degree in Physics and a Ph.D. in Engineering at UCLA. Dr. Baker was on the faculty of the Department of Astronomy at UCLA from 1959 to 1963 and the Department of Engineering and Applied Science at UCLA from 1963 to 1971 as a Lecturer and Assistant Professor. He was the head of the Lockheed's *Astrodynamics Research Center* in Bel Air, California and in 1964 joined *Computer Sciences Corporation* as the Associate Manager for Mathematical Analysis. In 1980 he was elected President of *West Coast University*, an accredited university for the adult learner now operating under the auspices of *American Career College* in Los Angeles. After retiring from West Coast University in 1997 as President and Professor of Engineering, Dr. Baker became the Senior Consultant for *Transportation Sciences Corporation* and *GRAVWAVE© LLC*. He won the UCLA *Physics Prize*, was recipient of the *Dirk Brouwer Award* for outstanding contributions in astrodynamics and orbital mechanics, is a Fellow of the *American Association for the Advancement of Science* and was a recipient of the *Outstanding Man of the Year* Junior Chamber of Commerce award in 1965 presented to him by Ronald Reagan. Dr. Baker was Vice Chair person of the first International Gravitational Wave Conference at the MITRE Corporation in 2003, Honored Professor *Chongqing University*, China 2004, and was the author of several textbooks and over one hundred company reports, symposium papers, and journal articles in the area of astrodynamics and celestial mechanics including *An Introduction to Astrodynamics* (1960) with Maud W. Makemson and *Astrodynamics: Applications and Advanced Topics* (1969). Dr. Baker has been interested in the dynamics of gravitational fields since the 1950's and gravitational-wave research since the early 1960's and holds five patents in the area of gravitational-wave generation. Please also see: www.drrobertbaker.com.)