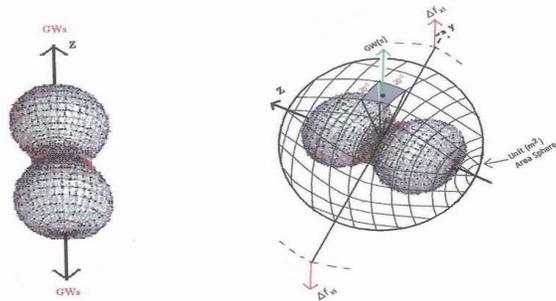


Gravitational Waves

The World Of Tomorrow, a Primer



Robert M L Baker, Jr.

This Book is dedicated to my Wife
Bonnie Sue Baker, MBG



(June, 2016)

Who in the 1960s suggested to
me "Why don't you work on
gravitational waves? I have a
feeling they may be important
in the future!"



Gravitational Waves: The World of Tomorrow
a Primer

FOREWORD

I have been a member of Dr. Robert Baker's Gravitational-Wave Team since 1999. However, our relationship goes back further to when I was preparing for my doctorate at the Massachusetts Institute of Technology. Many of us utilized Dr. Baker's textbooks in Astrodynamics. Many of his orbit-determination concepts progressively led to my selection as Eagle Pilot of Apollo XI and to the successful first Moon landing. Those

were exciting times and somewhat similar to today. With the launch of Sputnik and my journey to the Moon a new era in the world of tomorrow arrived: The Space Age!

Now, having actually detected gravitational waves, another new world of tomorrow has arrived: The Gravitational Wave Era! We are now on edge of learning more about the merger of black holes from low-frequency gravitational waves detected recently by LIGO. We can learn even more at the higher end of the gravitational-wave frequency spectrum, possibly about higher-order dimensions, multiple universes, how the universe started ... the Big Bang!

But now of even greater practical importance is the potential use of high-frequency gravitational waves for communication. Since, like gravity itself, these waves go through all matter unattenuated, not absorbed like microwaves. They propagate almost without absorption though interstellar space – and, for example, could convey messages from the star Antares to Earth or from Mars cyclers back to Earth. The high-frequency gravitational wave advantage would be that direct

communication can be maintained without relays even if Mars or the Moon is between the cyclers and Earth. Here on Earth, there would be no need for microwave or cell phone stations, cables or even relay satellites – the ultimate wireless system! However, that is not the main reason I recommend your reading this book. I believe what the world needs are not many more highly trained scientists and engineers, but a greater knowledge of those of you without advanced scientific university background, business people and others with only high school training in science and mathematics. All of us should achieve some fundamental understanding of the basics of science and engineering, now that understanding should include gravitational waves. That is the purpose of this very instructive book and I strongly urge you to read it.

Dr. Buzz Aldrin

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PREFACE

This volume is a *primer* that presents the most basic elements of gravitational waves (GWs). It is meant to fill the gap between general news articles and technical treatments in order for the layperson as well as for those readers with considerable scientific background to understand better gravitational waves as well as the potential of gravitational waves in the *world of tomorrow*.

There is always difficulty in writing a book that is valuable reading for persons having different educational backgrounds. Freshly minted PhDs in the physical sciences may find this book too elementary or glossing over important science. Those who measure their last exposure to introductory science courses in decades, may find the book too challenging. In order to bridge this educational gap, five of the more technical sections of the book are optional reading. The reader who chooses to bypass these sections will also find that careful reading of chapters 1 through 4,7,10 and 12 and simply skimming the other chapters, will provide them valuable insights concerning gravitational waves. Equations and arithmetic involved in utilizing such equations are included in the book as being essential to the understanding of gravitational waves. In this regard, an extensive nomenclature of symbols and list of important equations provides a self-contained key to all of the physics and astronomical nomenclature utilized in the book and each equation definition includes a reference to the chapter in which the term or equation is used. A sufficient prerequisite for the book would be a high school course in astronomy, physics and/or engineering.

The prerequisite mathematic background would be algebra, solid geometry and trigonometry. Course or courses in calculus would be valuable, but not essential for the reader.

In general, this book presents compelling routes for individuals in order for them and their organizations to take advantage of the new technology of gravitational waves. Those gravitational waves at the high-end of the gravitational-wave frequency scale may have practical applications. Such high-frequency gravitational waves or HFGWs seem to be of little interest to much of the current research and news media. This neglect is unfortunate since HFGW research, like low-frequency gravitational wave research, is **not** speculative and should be brought to the attention of all parties interested in gravitational waves.

In the Literature Survey Appendix of this book *are in excess of 600 references*. The majority of these references are directly related to HFGW research. Many of them are peer-reviewed and published in recognized journals and conference proceedings dating back to the 1960s. The important points of this considerable HFGW research are spotlighted in this volume although gravitational waves of all frequencies are discussed.

The Literature Survey references also serve as a key to the literature for the purposes of self-study or research. They are in chronological order and are annotated and divided into categories of:

Gravitational Waves Basic References

Low Frequency (LF) GWs from Orbiting Objects and Black Hole coalescence (mHz – kHz)

Interaction of Electromagnetic and Gravitational Waves (100 kHz – GHz)

Terrestrial or Laboratory Generation of High-Frequency Gravitational Waves (HFGWs 100 kHz – PHz)

High-Frequency Gravitational Wave (HFGW) Detectors

HFGW Applications

HFGW Propulsion and Gravity Modification

Cosmology: Relic and Primordial Background (HFGW: kHz – THz)

Gravitational Collapse

(Some References are in more than one category.)

The medium through which gravitational waves move, spacetime, is described in Chapter 1. Spacetime's most difficult to understand dimension, *time*, is analyzed by means of light cones in Chapter 2. Gravitational waves are destined to unlock the secrets of the beginning of our Universe, cosmology. In order to grasp cosmological concepts an understanding of entropy is essential and a simplified description of entropy is provided in Chapter 3. Chapter 4 involves the actual definition of gravitational waves and comparison with other waves. Chapter 5 provides a history of gravitational waves and introduces the basic quadrupole equation from general relativity. Chapter 6 discusses natural sources of low-frequency gravitational waves, or LFGWs, such as the merger of binary black holes, supermassive black holes and neutron stars. Such mergers will enhance our understanding of dark energy and the history and composition of the universe as a whole. The use of interferometers, such as the Laser Interferometer Gravitational Wave

Observatory or LIGO and the proposed Laser Interferometer Space Antenna (LISA) as well as its pre-deployment LISA-Pathfinder mission are discussed in this Chapter.

The reader is introduced to high-frequency gravitational waves, or HFGWs, in Chapter 7. The concepts of diffraction as well as a detailed analysis of the gravitational-wave generation radiation pattern are also presented in this chapter. In Chapter 8 cosmological natural sources of high-frequency gravitational waves from the early Universe are described. In Chapter 9 several possible laboratory sources of HFGWs are discussed.

These laboratory HFGW generators are still in the early development phase. Their possible practical application to communications awaits that development. The same could be said about radio waves before Marconi generated them in the laboratory 25 years after Maxwell published [“A Treatise on Electricity and Magnetism”](#) in 1873. Even though there was no successful radio-wave generator or crystal radio detector at that time, the Treatise stimulated many people to experiment with the concept of radio communication. In the literature survey, Appendix of this book can be found a rich collection of hundreds of HFGW references that may also serve to stimulate the development of HFGW communication as did Maxwell’s Treatise for radio communication. Eight designed or actually built high-frequency gravitational wave detectors or receivers are introduced in Chapter 10. Specifically, the Cruise-Ingley Birmingham University and the Li-Baker Chongqing University high-frequency gravitational wave detectors are described in more detail. Such high-frequency gravitational wave detectors may allow for the reception and analyses of primordial high-frequency waves from the early Universe. These waves could have

been produced in the period of inflation or “The Big Bang”. Unlike light photons, high-frequency gravitational waves would have traveled without attenuation through the newborn Universe. If primordial high-frequency gravitational waves and those from the so-called “brane world” were detected, then extra dimensions of space discussed in Chapters 1 and 11 might be sensed.

Although considerable theoretical work has been published since the 1960s, so far none of the HFGW astrophysical sources from the early Universe have produced signals that have been detectable by these eight different HFGW detector systems. There is a similar situation for the single interferometer detector system (including LIGO and the European Virgo) developed for the detection of LFGWs, whose future development was suggested in 1972 by Rainer Weisse of MIT, but formally announced in 1992. That system’s detection of the theoretically predicted black-hole merger LFGWs emissions was finally announced after 24 years of research and development and a total expenditure of over a half billion dollars of research funds. Eventually, following LIGO’s example, detection of early Universe HFGWs emissions may also be expected.

Chapter 11 discusses miscellaneous opportunities and concepts; a new approach to theoretical cosmology, entropy, parallel universes, or “realities,” and even presents a theory on time travel between universes that could be tested by the detection and analyses of gravitational waves. Chapter 12 considers the very practical applications of high-frequency gravitational waves, especially to global communications, *which is expected to change the world of tomorrow*. Applications of high-frequency gravitational waves to the Search for Extraterrestrial Intelligence or SETI and to interstellar travel, “starshot,” are also presented in this final chapter.

The proofreading by Pennee Conlee Hull, Robin Baker Fell and Diana Dunn Walker is very much appreciated. Ames Reed did an excellent job with many of the scientific drawings. Professor Fangyu Li was instrumental in developing the cosmology sections of Chapter 8. Professor R. Clive Woods provided me with important quotations and information, especially on gravitational-wave optics. Gary Stephenson and Thomas Lane contributed many scientific insights. Dr. Eric Davis provided much of the most up-to-date reference material for this Book and especially for the propulsion section of Chapter 12. Fred Noble, of Wintec Corporation in Palm Springs, California, backed all of the several gravitational-wave patents -- without his assistance, no such patents would have been granted. Transportation Sciences Corporation provided the financial support for the preparation of this Book. And, finally, thanks to my Economic Round Table of The California Club fellow Executives for putting up with yet another presentation of parts of this book on gravitational waves.

Robert M L Baker, Jr., PhD, November 15, 2016

Postscript

On June 17, 2008, a research group called the JASONS, composed of very influential and respected university scientists, was given a briefing on the generation, detection and applications of high-frequency gravitational waves (HFGWs). The [JASON Report \(JSR-08-506\)](#) on that briefing was published in October 2008. The Report was widely distributed to the US scientific community and various press organizations reported it. The JASON Report stated that “Our main conclusions are that the proposed applications of the science of HFGW are fundamentally wrong; that there can

be no security threat; and that independent scientific and technical vetting of such hypothetical threats is generally necessary. We conclude that previous analysis of the Li-Baker detector concept is incorrect by many orders of magnitude ...” The author of the JASON Report’s basic premise for generating HFGWs was: “*A basic mechanism for generating a HFGW is the direct conversion of an electromagnetic wave into a gravitational one of the same frequency by a strong static magnetic field. This **Gertsenshtein process** is idealized in Figure 3.*” In addition the Report states: “Proposed HFGW detectors *have generally been based upon versions of the inverse **Gertsenshtein process.***” These statements are both incorrect. The **Gertsenshtein process** or effect was published in 1962: M. E. Gertsenshtein, “Wave resonance of light and gravitational waves,” *Soviet Physics JETP*, **14**, Number 1, pp. 84-85. The effect is extremely weak and is **not** utilized in most of the modern HFGW generation, detection or applications. **Specifically, the Gertsenshtein process is not involved in any of the analyses in this Book and the JASON Report does NOT apply to this text.**

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EXERCISE SOLUTIONS

1.1 The sports car will back down a spiral below the origin to -1 minute, -2 minute, -3 minute, etc. points.

1.2 The pendulum period will be increased, so at (a) it will be further up the time axis (greater time) and more to the right.

2.1 The trajectory would start out at the coordinate of -1 hour down (the time axis of the cones) and 100 miles out from the polling place or origin of both time cones. It would be a straight line ending at

the 0 hour (pole closes) point and 50 miles out from the polling place at the cone's axis. The voting was missed and not cast!

2.2 The starship Enterprise trajectory would start out at the origin of the upper cone (polling place at the time 0). After one hour it would have traveled' and spread the election results, to the 200-mile point out from the upper cone's axis. Its own light cone would be 100 miles broader at the one-hour point than the one hour point of those who obeyed the speed limit and the Enterprise would have informed more people of the election results.

3.1 There are 5,000 chips (locations) plus 5 individual ski locations multiplied by 2 skies plus a single trash can = 5,011 microstates. The skies stored in their specified locations is one microstate and the chips in the trash can is the second microstate. It should be recognized, however, that there may be several alternative answers! Just explain them.

3.2 The simplified model associates the escape velocity (or speed) with the speed of light. The mass of the black hole remains the same. Therefore, a higher escape speed would be the result of a higher mass density. Essentially, more gravitational attraction to be overcome, so greater escape speed if closer to the mass center. Therefore, a denser black hole of the same mass would be smaller.

4.1 From Figure 4-1 for a water (and other) waves, the frequency, $\nu = v/\lambda$. In this equation v is the speed of the wave and λ its wavelength. Therefore, $\lambda = v/\nu$ and with $v = 10$ m/s and frequency equals one wave striking every ten seconds or 0.1 strikes per second or Hz, $\lambda = 10/0.1 = 100$ m long wavelength.

4.2 From Figure 4-1 for a gravitational wave the frequency, ν , is also, $\nu = v/\lambda$ and solving for the wavelength, λ , we again find $\lambda = v/\nu$. In this case $v = 3 \times 10^8$ m/s and frequency, $\nu = 10^8$ Hz, so that $\lambda = 3 \times 10^8 / 10^8 = 3$ meters.

5.1 From Chapter 4, the wavelength, $\lambda = v/\nu$. For GWs moving at light speed $v = 3 \times 10^8$ m/s, therefore, at the Weber Bar the wavelength = $3 \times 10^8 / 1.66 \times 10^3 = 1.81 \times 10^5$ m or 181 kilometers.

5.2 From Figure 5-4 one can apply trigonometry, that is $\tan(\Delta\theta) = \text{Opposite-Side}(\Delta f) / \text{Adjacent Side}(200N)$. So that for $\Delta\theta = 1^\circ$, we have $\tan(1^\circ) = 0.01745 = (\Delta f)_i / 200$ N. So that solving for Δf one finds $\Delta f = 3.49$ N.

6.1 Since there are 9.46×10^{15} meters in a light year, at a distance of 4.4 light years for PSR1913 +16, its distance at the distance of the Alpha Centauri system, would be $R = 4.16 \times 10^{16}$ meters. We again assume that its power of 7.34×10^{24} watts, is spread evenly over a sphere of radius R since low-

frequency gravitational waves (LFGWs) are completely diffracted away and have no preferred directivity (which makes LFGWs a very poor choice for GW applications). The sphere's area is about $2.18 \times 10^{34} \text{ m}^2$ so that the GW's power flux at the Earth's distance would be about $S = 3.37 \times 10^{-10}$ watts per square meter. By the way, if we applied the key equation from Chapter 9,

$$A = 1.28 \times 10^{-18} \sqrt{S} / v_{\text{GW}} \text{ m/m}, \quad (9-5)$$

with the GW frequency $v_{\text{GW}} = 1/\text{period of PSR13 +16} = 1/1.395 \times 10^4 \text{ s} = 7.17 \times 10^{-5}$ per second or Hz, we find the maximum GW amplitude $A = 2.8 \times 10^{-21}$ m/m, which might be detected by LIGO.

6.2 As in Exercise 5.1, from Chapter 4, the wavelength, $\lambda = v/v$. For GWs moving at light speed $v = 3 \times 10^8 \text{ m/s}$, therefore, at the low chirp frequency Hz of 35 Hz the wavelength $= 3 \times 10^8 / 35 = 8,570$ kilometers and at 250 Hz high chirp frequency, when the black holes are near to coalescence, the wavelength is about 1,200 kilometers.

7.1 From Equation 7-1

$$\sin(\theta_{\text{diff}}) = \lambda/w = c/v$$

Therefore, with $c = 3 \times 10^8 \text{ m/s}$ and $v_{\text{EM}} = 2.5 \times 10^9 \text{ Hz}$ (2.5 GHz), $\sin(\theta_{\text{diff}}) = 0.12$ and $\theta_{\text{diff}} = 6.9^\circ$. The HFGW frequency is twice the EM frequency, so for the GW $\sin \theta_{\text{diff}} = 0.06$ and $\theta_{\text{diff}} = 3.4^\circ$.

7.2 From Table 7-1 the fraction of radiation in the 10^0 segment is 0.3445 and contains about the 34 percent of the radiation.

8.1 Roughly ; an average or "root-mean-square" (rms) spacetime strain of $h_{\text{rms}} = 10^{-10}$ m/m.

8.2 8.2 The speed of increase of the radius to a point on the surface of the "little universe" of Figure 8-7 is $0.01 \text{ m} / 10^{-34} \text{ s} = 10^{32} \text{ ms}^{-1}$. To make this to be the speed of light, the clock in the little early universe would need to be changed by $10^{32} / 3 \times 10^8 = 3.33 \times 10^{23} \text{ s/s}$. Note that during one second (one click of the second hand on the clock in our current Universe), the time moves in the little universe $3.33 \times 10^{23} \text{ s}$ or, since there are about 3.15×10^{16} seconds in a billion years, about $3.33 \times 10^{23} \text{ s} / 3.15 \times 10^{16} = 10.6$ million years. Sounds like a lot of time, but in the little early universe its first 10^{-34} seconds is still only $10^{-34} \text{ s} \times 3.33 \times 10^{23} \text{ s/s} = 3.33 \times 10^{-11}$ seconds. If the clock time in the early Universe read $3.33 \times 10^{23} \text{ s}$ and today was 10^{-34} s , then the clock speed in the early Universe had been speeded up by the factor $3.33 \times 10^{23} / 10^{-34} = 3.33 \times 10^{57} \text{ s/s}$. If the

standard meter is shrunk by 3×10^8 , then the time calculation would be unaffected since the given 1 cm radius and time of 10^{-34} seconds in today's Universe remains unchanged.

9.1 The actual hypothesized force created by a miniaturized FBAR is proportional to the FBAR area so the square of the scale factors, that is for Case a) $\Delta f_a = (2 \text{ Newtons}) \times (1/100)^2 = 2 \times 10^{-4} \text{ N}$ or Newtons. The inverse of the frequency of an FBAR, Δt in seconds is, as already noted, proportional to the thickness that is, the thinner the FBAR the higher its excitation frequency and the smaller the resulting Δt . For the non-miniaturized FBAR $\Delta t = 4 \times 10^{-10} \text{ s}$ so Case a) $\Delta t_a = 4 \times 10^{-12} \text{ s}$ and $v_{EM} = 250 \text{ GHz} = 2.5 \times 10^{11} \text{ Hz}$. The effective or average radius to the FBAR array = $r_B = r_{rms} = \sqrt{[(r_1^2 + r_2^2)/2]} = 39.5 \text{ m}$. The volume of the generator's FBAR array is $V_B = L \times \pi(r_1^2 - r_2^2) = 1,178,000 \text{ m}^3$. Therefore, $N_{Aa} = V_B / V_a = 1,178 / 1.33 \times 10^{-19} = 8.86 \times 10^{21}$. The main factor in the power equation Eq. (5-6) (or Eq. (5-12)), $(2r_A \Delta f_a / \Delta t_a)^2_{Aa} = (2 \times 3.95 \times 2 \times 10^{-4} / 4 \times 10^{-12})^2 = 1.56 \times 10^{17}$ so $P_{Aa} = 0.5 \times N_{Aa} \times 1.76 \times 10^{-52} (2r \Delta f / \Delta t)^2_{Aa} = 1.22 \times 10^{-13} \text{ W}$.

9.2 The basic enhancement due to superradiance is according Eq. (9-4), for case A), a) at a meter distance is :

$$S(1)_{Aa} = (P_{Aa}/4)/(1.71/N_{Aa}) = (1.22 \times 10^{-13}/4) \times 10^{22}/1.71 = 0.18 \text{ W/m}^2 \text{ and } vS_{Aa} = 0.4242 \text{ and}$$

$v_{GW} = 500 \text{ GHz}$ (GW frequency is twice EM frequency) or $5 \times 10^{11} \text{ Hz}$. Therefore at one meter distance from the generator is $A_{Aa}(1) = 1.08 \times 10^{-30}$ and detectable by the Li-Baker HFGW Detector.

10.1 The National Astronomical Observatory of Japan HFGW Detector utilizes two recycling interferometers with arms about 75 cm long whereas the LIGO Interferometers are about 4 kilometers in length. The National Astronomical Observatory of Japan HFGW Detector is sensitive to about 100 MHz (10^8 Hz) whereas LIGO's LFGW detectors are sensitive to less than 2 kHz to a small fraction of a Hz.

10.2 The Gertsenshtein Effect was published in 1962 and considered the interaction of gravitational waves and electromagnetic waves, specifically light, under the influence of a magnetic field. The Effect is extremely weak and of little value in GW, especially HFGW, detection or generation. The Li Effect was developed by Fangyu Li of Chongqing University in China during the 1990s. Far different from the Gertsenshtein Effect, it relies on an Electromagnetic (EM) beam having the same frequency and direction as the HFGW to be detected. Its only similarity is that it utilizes a magnetic field perpendicular to both EM GW radiation direction and is roughly 30 orders of magnitude more effective than the Gertsenshtein Effect.

11.1 From Equation 11-7, $L_2^2 = (1 - v^2/c^2) \times L_1^2$ so their ratio of $(0.5)^2 = 0.25 = 1 - v^2/c^2$. Therefore, $v^2/c^2 = 1 - 0.25 = 0.75$ and $v^2 = c^2 \times 0.75 = 9 \times 10^{16} \times 0.75 = 6.75 \times 10^{16}$ so the $v = 2.6 \times 10^8$ m/s.

11.2 Since the event occurred at one *instant* of time, ALL the horses would be transferred back and forth at the same time from one osculating universe (“point” in the STU). Thus there would be no change from their Gaussian distributional along the track. Of course, the location of the “starting gate” and “finish line” have no relevance except to set the imaginary scene. It is only the distribution of the vacillating sub-nano particles (“horses”) that counts.

12.1 The propulsion thrust would be like that of EM-propulsion thrust. That is, similar to a Flashlight since both forms of radiation travel at the speed of light and carry very little momentum. Furthermore, only HFGWs (not LFGWs) could be focused in the aft StarCraft direction and the HFGW generation process, discussed in Chapter 9, would require more energy for a given thrust value than thrust created by chemical reaction. Conventional propulsion means, for example, burning hydrogen and oxygen, is far more efficient than either the on-board generation of EM or GW would be.

12.2 From Table 12-1, the time is 40 million years of ability to practice interstellar communication. From Table 12-2 it is $N = 1.48 \times 10^{16}$ potential intercommunicating civilizations. From Table 12-3 $N_2^2 = 2.2 \times 10^{20}$ and the messages per year, f_2 , 5.5×10^{15} . Therefore, the messages per day is $5.5 \times 10^{15} / 365 = 1.5 \times 10^{13}$ and per hour is 6.3×10^{11} . Essentially, the longer the lifetime of advanced civilizations the more chance there is to intercept their interstellar messaging.

PRAISES DR BAKER'S NEW BOOK

“...I worked my way through your book on gravitational waves. I believe I understood the basics of it, though not all of the details. ... But I certainly learned far more about gravitational waves than I previously knew, and I am grateful for the experience. You have a wonderful gift for explaining the subject with clarity.”

Joseph Schulman, MD

Founder and Chairman of the Board of the Genetics & IVF Institute

President of the “Committee of 25”

Palm Desert, California, USA

“Now, having actually detected gravitational waves, another new world of tomorrow has arrived: The Gravitational Wave Era! We are now on edge of learning more about the merger of black holes from low-frequency gravitational waves detected recently by LIGO. We can learn even more at the higher end of the gravitational-wave frequency spectrum, possibly about higher-order dimensions, multiple universes, how the universe started ... the Big Bang!... I recommend your reading this book. I believe what the world needs are not many more highly trained scientists and engineers, but a greater knowledge of those of you without advanced scientific university background, business people and others with only high school training in science and mathematics. All of us should achieve some fundamental understanding of the basics of science and engineering, now that understanding should include gravitational waves. That is the purpose of this very instructive book and I strongly urge you to read it.”

Buzz Aldrin,

Pilot of the first manned spaceship to land on the Moon

Melbourne, Florida, USA

“Among other excellent discussions this book presents to me an entirely new concept in multiuniverses. Its Chapter 11 describes the osculation or ”kissing” of other universes with our Universe, not the largest scales of our Universe, at huge black holes or “worm holes,” but instead at the smallest scales where the so-called quantum-mechanical “frenzy” or “foam” exists.”

The Rev. Dr. Cynthia Forde

Association of Professional Genealogists

Hempstead, Texas, USA

“Fascinating explanation of how we will communicate and possibly travel through space upon harvesting the phenomenon of Gravitational Waves. Written for dummies (like me) and intellectuals alike by, UCLA Professor Robert Baker, the world’s foremost expert on the subject. Read the forward by astronaut Dr Buzz Aldrin. I personally am looking forward to experiencing this new "Wave".

“I am an Amazon Kindle Fanatic with around 500 books archived in my kindle library, I occasionally buy hard copies as I did with this marvelous book. I did a lot of back and forth reference and consider Gravitational Waves a must hard copy purchase not only for its Graphics and Photos but for its pending historical value.”

William B. Stevenson, Jr.

Palm Desert, California, USA

“Not familiar with the science of gravitational waves and yet we live in a world that is influenced by gravity, I thought to read this new book by Dr. Robert Baker. What a fascinating and well written read. Gravitational waves influence on time travel and communicating through the core of earth sans satellites was thoughtfully presented and fascinating to read. This book, unto its own, is a TIME TRAVELER for the curious inventor seeking create for the world of tomorrow.”

Robin Fell

Inventor

Santa Barbara, California, USA

Please visit www.gravwave.com

88 Line 17 2556 Replace: “will generate a HFGW of the same frequency as the EM wave. As will”

by: “will generate a HFGW of the same frequency as the EM wave and vice versa. As will”

89 6th Line UP 2583 Replace: “ers when measured by this greatly contracted or vexpanded “Standard” by: “ers or a few micrometers when measured by this greatly contracted or expanded “Standard”

2nd and 3rd Lines Under Figure 8-6 2587 -2588 Replace: “universe not exceed the speed of light? Hopefully, the detected HFGWs may provide the answer!” by: “universe not exceed the speed of light? The ticking rate of the fast or slow clocks is here suggested to be related not only to time dilatation to be discussed in Chapter 11, the strength of the gravitational field (Margalit, Y. et al. *Science* 349, 1205-1208), where clocks move slowly, but also the **speed of time** may be related to the value of time itself. Of course time, like east-west, north-south and up-down, is a direction and directions do not have “speed” so we are discussing the **speed of time as a rate of progression of time along the dimension of time**. During a possible inflation of the early Universe (time is just getting started), clocks there might need to be very “fast” in order for the “material” of the early, possibly rapidly inflating, Universe not to exceed the speed of light as suggested in Exercise 8.2. According to Julian Barbour ([arXiv:0903.3489v1](https://arxiv.org/abs/0903.3489v1)): “Clocks are useless if they do not march in step for otherwise we cannot keep appointments. Therefore it is not a clock that we must define but clocks and the correlations between them as expressed in the marching-in-step criterion.” But when they do not march in step that is where time as a “duration” becomes interesting. Again according Barbour “Occam’s razor tells us to avoid redundant elements. All we need are differences. Indeed, the passage of time is always marked by difference...” Consider an analogous hypothetical situation: Suppose you are a trainer of a mile runner who you just measured as doing a four-minute mile. Another trainer says that cannot be correct “Your runner could not have improved that much, your stopwatch must be running slow since we all measured that he only ran a five-minute mile last year.” Well, you argue “No, my runner’s speed has not improved, he is running at his usual **intrinsic** speed. You all had stopwatches that were running fast and miss-measured my runner’s speed and transient time!” Specifically, the “old” (last year’s) stopwatches were moving $5/4 = 1.25$ times faster than today’s stopwatches. Therefore, it may well be that the “stop watches” in the early universe were moving much faster than the watches of today. Essentially, an experiment may not be required to explore this concept. If there is a nuclear or molecular or other transient time (like a runner’s **intrinsic** time to run a mile or a Muon’s decay time) that has been measured accurately by atomic clocks, then one should examine past records and determine if a statistically significant reduction of the transient, e.g., Muon decay, time over several years has occurred. If so, then their atomic clock “stopwatches” must have been all running a little fast in the past and the speed of time was different. (Please see Section XVII and Appendix B of:

<http://www.gravwave.com/docs/Beckwith%20%282017%29%20History%20lessons%20from%20the%205th%20Solvay%20meeting.pdf>.)

There also may have been a change in the apparent speed of light. If the Standard meter was very small, then the early speed of light would have been **apparently** faster in the past and now apparently slower with current, larger meter. Similar to a mile-runner running an effectively

shorter mile at his **intrinsic** speed – it takes him “less time” so appears to be running faster. Possibly atomic clocks are still very slightly slowing down, the Muon’s decay time and/or the speed of light very slightly decreasing since the Big Bang. There is ongoing debate over the meaning of time and the constancy of the speed of light and other astrodynamical constants and the foregoing analyses and notions are open to considerable debate. But hold on! If in the mile-runner analogy the “stopwatches” are running fast, then the shortening of the mile may be completely offset by the speed of time increase and the apparent speed of the runner can be completely or partially offset and the intrinsic and apparent speeds could possibly be equal. Therefore, the intrinsic and apparent light-photon speeds could be the same in the early Universe. In any event, the early universe might be like a miniaturized *World* where “... the craftsman moves very fast indeed” as previously mentioned. Since the early Universe may be in relatively rapid motion, gravitational waves of high frequency may be generated. Thus the detection of high-frequency gravitational waves could reveal the truth.

90 The Figure number should be 8-7 **2590**

After 3rd line **2591** (after Figure 8-7), Insert: Einstein stated “The only reason for time is so that everything doesn't happen at once.” It should be added that the only reason for space is that everything doesn't happen at one place – except, perhaps, at the beginning of a universe. There is a problem here. As will be discussed in Chapter 11 and mentioned in Chapter 2, a universe should be no-chaotic and there is cause and effect, that is, there is order or a sequence in how things influence one another across time and space – e. g., as in the light cones: votes cast and counted (cause) and then reported (effect). As Philip Ball (*Nature* **546**, p. 591) writes “... two particles *A* and *B* that have been prepared with ... ‘entangled’ properties ... for example if *A* has an upward pointing spin ... then *B* must be down and vice versa ... That means if one changes the spin on *A* it also (instantly) fixes the state of the entangled partner *B* – *however far away that partner is.*” Here’s a practical application: we want to have advance warning that the Klingons are attacking; so we entangle two electrons, keep one here at Space-command and have a Starship with the other several light years away. If the Klingons are spotted, then the Starship flips its electron’s spin. The other entangled electron also instantly flips and Space-command is immediately alerted to the Klingon attack! But according to Einstein’s special relativity of Chapter 11 nothing (no information) can move faster than the speed of light, *c*. So maybe the effects of *A* and *B* are determined by some other event acting on them both – a “bridge” of time perhaps. HFGW research may help define that bridge. (Andrew Beckwith, “... quantum teleportation ... the Einstein-Rosenstein Bridge...” *Journal of High Energy Physics, Gravitation and Cosmology* **3**, No. 4.)

91 3rd Line UP **2623** Replace: “an assumed constant, light speed of 3×10^8 m/s? Suppose the standard” by: “an assumed constant, light speed of 3×10^8 m/s? If the clock time in the early Universe were 3.33×10^{28} s and today was 10^{-34} s, then by what factor would the clock in the early Universe need to be speeded up? Suppose the standard”

96 Line 12 **2724** 5th word over, Change 10^{35} to 10^{42}

102 Line 8 **2863** Third word over: Replace: “sothat” by: “so that”

108 5th Line under Fig. 9-7: **3065** Replace: “miniaturizing the FBARs or some excitable MEMS vibrator to nanom-“ by: “miniaturizing the FBARs or some excitable MEMS vibrator (such as a nanoscale spintronic oscillator, *Nature* **547**, p. 428) to nanom-“

111 Line 18 **3177** Replace: “example, a hundred times smaller FBAR of Case A) a) has 100³ times” by: “example, a hundred times smaller FBAR of Case A) a) of Exercise 9.1 has 100³ times”

112 Line 7 **3205** Replace: “to excite them would be by pulsed lasers. Of course, EM wave excitation” by: “to excite them would be by pulsed lasers, banks of them synchronized together. Of course, EM wave excitation”

120 3rd line UP **3392** Replace: “effect” by: “Effect”

121 Last three Lines on page **3410-3412**

Replace: “Woods and published in a 2011 edition of the *Journal of Modern Physics* [2011, Woods, ...]. A drawing of the Li-Baker HFGW Detector is presented in Figure 10-9.”

by: “Woods and others published in a 2011 edition of the *Journal of Modern Physics* [2011, Woods, et al **High-Frequency Gravitational Wave (HFGW) Detectors**]). A drawing of the Li-Baker HFGW Detector is presented in Figure 10-9. With the superconductor magnetic field on, both noise and the signal perturbative photon flux (signal PPF) photons caused by the interaction of Gaussian-beam and coincident HFGWs (Li-effect) are detected at microwave detectors #1 and #2. With the magnetic field off only noise photons are detected. The difference between these detected photons then signals the presence of HFGWs. A basic problem is, as usual, noise – especially standard-quantum-limit noise inherent in the observation process itself caused by “quantum back action.” Since, according to Heisenberg uncertainty, the photons involved in the observation themselves change what is being observed (slightly changing the geometry and/or time of arrival of signal PPF photons or slightly “moving” or “hitting against” what is being observed so it is not where it was when it was observed) and are also noise sources.”

126 line 1, **3486**, word 6 Replace: “dilatation” by “dilation”

130 line 5, **3594**, word 9 Replace: “dilatation” by “dilation”

147 6th and 7th Lines below Table 12-1, **4163** and **4165**

Replace: “about 400,000 years C to D. However, evolution can proceed rapidly according to Elizabeth Pennisi [2016, HFGW Applications]. Various” By: “about 400,000 years C to D. However, evolution can proceed rapidly according to Elizabeth Pennisi [2016, **HFGW Applications**]. There is also conjecture about the inevitability or improbability of the likelihood of intelligent life actually forming in our Universe. As Adrian Woolfson writes (*Nature* **357**, p. 362) ”Gene editing ... allowing us to expunge unfavorable aspects of ourselves – such as our susceptibility to diseases and aging – while enabling the introduction of more appealing features ... humanlike organisms would be a near inevitability ...” Various”

229 **6782 – 6794** Replace Exercise 8.2 by:

8.2 The speed of increase of the radius to a point on the surface of the “little universe” of Figure 8-7 is $0.01 \text{ m} / 10^{-34} \text{ s} = 10^{32} \text{ ms}^{-1}$. To make this to be the speed of light, the clock in the little early universe would need to be changed by $10^{32} / 3 \times 10^8 = 3.33 \times 10^{23} \text{ s/s}$. Note that during one second (one click of the second hand on the clock in our current Universe), the time moves in the little universe $3.33 \times 10^{23} \text{ s}$ or, since there are about 3.15×10^{16} seconds in a billion years, about $3.33 \times 10^{23} \text{ s} / 3.15 \times 10^{16} = 10.6$ million years. Sounds like a lot of time, but in the little early universe its first 10^{-34} seconds is still only $10^{-34} \text{ s} \times 3.33 \times 10^{23} \text{ s/s} = 3.33 \times 10^{-11}$ seconds. If the clock time in the early Universe read $3.33 \times 10^{23} \text{ s}$ and today was 10^{-34} s , then the clock speed in the early Universe had been speeded up by the factor $3.33 \times 10^{23} / 10^{-34} = 3.33 \times 10^{57} \text{ s/s}$. If the standard meter is shrunk by 3×10^8 , then the time calculation would be unaffected since the given 1 cm radius and time of 10^{-34} seconds in today’s Universe remains unchanged.