ORION Trapezium

April, 2016 Volume 6 Issue 4

WHATS INSIDE…

Who are we?

ORION was founded in April, 1974, by a group of scientists at the United States Department of Energy facilities in Oak Ridge, Tennessee. Our original goal was to perform correlated, instrumented observations of atmospheric and astrophysical phenomena. Since then, we have expanded in many directions, including optical and radio astronomy and instrument design / construction. Want to know more? See the last page.

Future Events:

ORION Meeting to be held at 1900 Hours (7 PM) on Wed. April 20, 2016

Venue: The Historic Grove Theater on Randolph Road, Grove Center Oak Ridge

Abstract: (on right)

TAO Public Stargaze

- ***Dates***:
  Saturday, May 7, 2016
  Saturday, May 21, 2016
- ***Where***: Tamke-Allan Observatory (TAO), Rockwood, TN, 37748, USA
  GPS: 35.80 North, 84.62
- **Time**: 7:30 pm - 12:00 am
- **8 PM Program: Come and help show the skies to our visitors.**

APRIL MEETING ANNOUNCEMENT

Program: **"On the Origin of the Universe and Life on Earth"**

Dr. Robert Compton
The University of Tennessee

Abstract: See Below

TAO Notes: ORION people are invited to arrive early (if announced on email) with telescopes to prepare for evening viewing and share snacks. Bring a telescope, red flashlight, and munchies. First time visitors drive out before dark!
Map: http://www.roanestate.edu/obs/visit.htm

This month's editors:

Roy Morrow and David Fields

Email Trapezium submissions to: rmorrowb44@gmail.com

On the Origin of the Universe and Life on Earth

As a result of enormous progress in the science of Cosmology we now know the age of our observable Universe to four decimal places (13.72 billion years). Our Earth consists of a speck of rock gravitationally attracted to the sun at the edge of the Milky Way Galaxy which is nestled within the Virgo super-cluster of Galaxies. Human history is pockmarked with attempts to understand the Universe and our place in it. In the past 100 years, guided by Einstein's description of gravity, space and time together with new astronomies and the observations of the cosmic background radiation, we can now speculate as to the origin of the Universe. However the origins of life, unlike the Origin of the Species, is still somewhat of a mystery…… but science is working on this problem.

This talk will present some recent scientific ideas as to the beginning of the Universe from nothing[1]. We will begin with a discussion of the vacuum, propagation of light in a vacuum, and vacuum zero-point energy as it relates to Einstein's Cosmological constant. We will end with a brief presentation of observations supporting the existence of Dark Energy and Dark Matter. These observations in Astrophysics promise to rewrite the laws of physics.

We will follow the estimates of the age of the Earth from the Biblical to the present scientifically accepted value of 4.54 ± 0.05 billion years old. Life as we know it has a more recent history. In the 1950's Miller and Urey[2] created a discharge in a test tube containing vapors of water, methane, ammonia and hydrogen. After a period of time they reported 11 of the 20 known amino acids which support life. The implications for the prebiotic origins of life was great, however, the amino acids produced were both "right" and "left" handed (racemic mixture) where it is known that the amino acids of life are almost exclusively "left" handed. There has been considerable research and speculation as to how left-handed amino acids could be produced on Earth (or outer space and deposited on Earth). My research over the past 20 years at the University of Tennessee has been focused on this question. I will discuss how circularly polarized microwaves acting on a racemic mixture might produce enantiomerically pure (one-handed) amino acids. In another study a recent graduate student (Jason Lambert) and UT professor (David Keffer) and I have shown experimentally and theoretically that many racemic liquid mixtures consist of "clumps" of molecules of specific handedness. This is similar to the observation of Pasteur who observed chiral crystals of tartaric acid produced from wines contain *only* right or left handed molecules. Thanks to Darwin we have a good idea of the evolution of the species and science is working on the origin(s) of life. However, as for consciousness I can only quote Descartes: *Je pense, donc je suis* .

As an experimental physicist every effort will be made to make the presentation understandable at the high school level.

1. See e.g. Krauss, L.M. "A Universe From Nothing" Simon and Schuster, Inc.
2. Miller, S. L. (1953). "Production of Amino Acids under Possible Primitive Earth Conditions" *Science* **117** (3046): 528–9. Miller, S. L.; H. C. Urey (1959). "Organic Compound Synthesis on the Primitive Earth". *Science* **130** (3370): 245–51

Robert N. Compton (Sr. Corp. Fellow Emeritus, ORNL; Professor Emeritus, Univ. of Tennessee)

Robert Compton Bio

Bob Compton was born in 1938 in Metropolis, Illinois, home of Superman. The Compton family moved to Oak Ridge in 1943 during WWII where his father worked at Y-12 on the Manhattan Project. He received degrees in Physics from Berea College (BA), the University of Florida (MS) and the University of Tennessee (PhD). At Berea he was interested in sports and choir and was awarded the Athlete Scholar Award in '58, and the Athlete of the Year Award in '59. During this time one summer

was spent working at Y-12 and three summers at K-25 with Union Carbide. He was a Senior Corporate Fellow at the Oak Ridge National Laboratory from 1965 to 1995 and has been a Professor of Physics and Zeigler Professor of Chemistry at the University of Tennessee until retirement in 2015. He was a Visiting Professor at the University of Aarhus, University of Paris, and the FOM Institute in Amsterdam. In 2001, he was an Erskine Fellow at the University of Christchurch, New Zealand. As an Erskine Fellow he also presented eight two-hour lectures on the Manhattan Project to the city of Christchurch. He is a Fellow of the APS, AAAS, and OSA. He also received the Beams Award from the APS and the Meggers Award from the OSA. His research interests include negative ions, laser spectroscopy, and molecular chirality. Outside interests include music and trout fishing.

Jennifer's Column

Humble Eloquence: An Evening in Oak Ridge with Nancy Grace Roman, 'Mother' of the Hubble Space Telescope

It would be an understatement to say that I didn't know what I was about to walk into on the evening of March 24, 2016. My only focus was on the notion that a former chief NASA astronomer would be presenting a lecture on the "…evolution of the universe from big bang to black holes" sponsored by Friends of Oak Ridge National Lab and the American Association of University Women. The topic of the lecture was enough to convince me to go. I'd learn something, I was sure, and at the end of the evening I'd return home feeling happy to have added one more nugget of information to my brain. It turned out to be more than that. Much more. To put it quite bluntly, at the time I was unable to fathom the depth of history that was brought before me by the 94-year old woman who commanded the stage that night. Nancy Grace Roman began her talk sitting in a chair before a group of about 150-200 people, with a presentation remote in one hand and her walker near the other. Right then, I knew I wanted to be like her one day. She gave a presentation that dealt with the essentials of observational astronomy: Hubble's discovery that the universe was expanding, the contributions of Einstein to our current

understanding of the fabric of space, the use of Cepheid variable stars to calculate distances in space, the existence of dark matter and black holes. It was a great lecture but I remember thinking that I knew (at least on a superficial level) most of it already. My bigger questions arose when I pondered the woman speaking before me: what had she been doing during her life that played a role in landing her before our group on that night? Plenty, I found out.

It's easy to forget that the preponderance of what we know about the universe comes from studying light, and as NASA famously stated, "not since Galileo turned his telescope toward the heavens in 1610 has any event so changed our understanding of the Universe as the deployment of the Hubble Space Telescope" (HST). Nancy Grace Roman played a major role in the development and funding of our beloved HST, and while she will be the first to say that it would have happened without her, she is nonetheless referred to as the "Mother of of the Hubble Space Telescope". Yeah, that telescope. The one that has made more than 1.2 million discoveries since is was launched on April 24, 1990 – almost 26 years to the day.

Dr. Roman's main influences as a young child were her parents. Her mother showed her the constellations (though she was a musician by trade) and her father gave her detailed answers to her science questions until she understood their meaning. After earning her doctorate in astronomy at the University of Chicago (in the presence of eventual Nobel Prize winner Subrahmanya Chandrasekhara, after whom the Chandra telescope is named) the 24-year accumulated six years of research experience where her spectroscopic studies of bright, sun-like stars revealed small variations in spectral lines that nobody had previously found to be of importance. Her analysis was that stars with higher amounts of heavy elements (younger stars) orbited the galactic center in a circular pattern within the galactic plane, while those with lower amounts of heavy elements (older stars) demonstrated a more elliptical pattern and strayed further from the galactic plane. Her observations gave astronomers some of their first clues regarding the evolution of the Milky Way galaxy. Her research in Chicago ended, however, when she realized that it was highly unlikely that she would reach tenure status due to her gender. She moved to the Naval Research Laboratory (NRL), working in the area of radio astronomy – a relatively new field that she felt might shed new light onto the understanding of the structure of our own galaxy. While she was not unhappy with the work that she did here (she was involved with the first radar measurements of lunar distance from the Earth, and was also the first to recognize that the galactic center was comprised of both thermal and non-thermal sources - though she was never able to demonstrate her research on the latter), she quickly realized that work at the NRL would require more knowledge in electrical engineering. During these early days, one was expected to make their own equipment and she did not want to start her education over. It is worthy to note that, prior to leaving the NRL, Dr. Roman would become the first U.S. civilian to travel to the Soviet Union after the start of the cold war, where she was a guest of the Soviet Academy of Sciences for the dedication of a new Armenian observatory. Her invitation came as a result of the research she had done at Chicago, and she soon realized that her work was bringing her recognition world wide.

As luck would have it (and I emphasize here that luck happens when preparation meets opportunity), NASA became a newly formed agency in October of 1958. Within six months, at the age of 33, Dr. Roman landed what would become her job for the next twenty years: Chief of NASA's Astronomy and Relativity Programs (she was the first to hold this position). Regarding her new role, she would later say that "One of the problems when I started with NASA was that the astronomers knew what they wanted to do and the engineers were perfectly willing to help them do it, but they couldn't communicate with

each other. So I felt that much of my time in, or at least an important part of my time in the early period, was acting as an interpreter between the astronomers and the engineers." To put it succinctly, she spent a good deal of her early days at NASA traveling the country to talk to astronomers and find out what they wanted, and to engineers to determine what could actually be done. What the astronomers wanted was the ability to place a telescope above the Earth's atmosphere in order to examine all wavelengths of light. What the engineers eventually made possible under her direction, planning and management were the Orbital Astronomical Observatories, the International Ultraviolet Explorer and the Hubble Space Telescope. It was her who encouraged the use of a charged couple device (CCD) for the HST camera. When funding of Hubble became a source of consternation, Dr. Roman was quick to determine that for the price of a movie ticket, the U.S. taxpayer would receive 15 years (actually, 25 years now) worth of science. She retired from NASA in 1979 and moved on to do contract work with Goddard Space Flight Center and McDonnell Douglas, eventually securing a role as the Director of the Goddard Astronomical Data Center. She seems to have been open to new challenges at every step of her life: acquiring a degree in astronomy during a time when women were not openly encouraged to do so, managing a new astronomy program in the midst of a cold war, finding funding for a new telescope when NASA was beset with budgetary issues and the Challenger disaster, and branching out into unfamiliar territory when faced with a career change at the age of 54 while simultaneously caring for her elderly mother.

The evening that I listened to her talk, Dr. Roman made very little mention of any of these extraneous adventures. In 2011, NASA established the fourth Technology Fellowship in Astrophysics in her name. The names attached to the other three are Einstein, Hubble and Sagan, but there was nothing said about this honor, either. Her presentation focused on teaching and sharing, a role that she has taken on since 'retirement' in 1997. She was eloquently demure, open to questions and generous with her time once the crowd had left. I thought of what she said regarding how her parents influenced her path the most, and once again was reminded of the good the O.R.I.O.N. group can do for the kids of all ages that we encounter: show them the constellations, and answer their science questions. I think we've got a pretty good pool of people to draw from in order to influence the mother – or father – of the next, grand space project that has yet to be discovered.

Gastronomy at TAO

Cloudy or clear astronomers and visitors will gather at TAO on family nights for stargazing and to enjoy the many *gastronomical* treats. On the April 2 family night the food was exceptional with the "alien bunny" cake provided by gastronomist Jim Long. The "alien" cake and a visiting "alien" are shown below. There were manly additional "healthy" body building treats.

Alien Bunny Cake

Alien after eating alien cake

ORIONITES waiting to defend the treats(from Aliens)

Parting Shot(s)

Shawn Harrison attended the first Pickett State Park Astronomy Weekend. This is his report along with his spectacular image of M106.

Pickett State Park Astronomy Weekend, April 1st and 2nd 2016

Located very close to the Kentucky border, Pickett is a wonderfully dark place to enjoy the night sky and as an IDAS designated park, they are very keen on preserving this resource. Ranger Monique Johnson has been the driving force behind this and has done an awesome job. The park works with the nearby city of Jamestown to provide education and awareness and the Mayor's assistant informed us of the outreach they are doing and have pledged to help maintain the dark sky status of the park. Pickett also has plans to provide astronomy designated spots in addition to the astronomy field, which is a short walk from the main hall and bunk houses. The Park will also be hosting Astronomy events July 9th, August 12th and October 8th.

Friday night was clouded out but Saturday night the clouds cleared and the wind died down around 11pm. Best SQM reading was 21.45. Well worth the 2 hour drive from Knoxville, there were many nice programs during the day, solar viewing, very nice hiking trails and many choices for accommodations.

Messier 106 in Ursa Major, 3 hours of 10 minute exposures
using a 10" SCT and SBIG STF8300c. Image by Shawn Harrison at Pickett Dark Sky Park
(Editors note: There will be an image from a local astrophotographer included in each Trapezium issue.)

Great Smoky Mountains National Park Star Party

The National Park Service Sponsors a Spring and Fall Star Party in Cades Cove. (a perspective by Roger Lane)

What a great evening at the GSMNP Cades Cove Spring Star Party held on Saturday April 2! Members from SMAS, KO and the ORION Astronomy Club gathered at the pavilion at the entrance to the Cades Cove Loop Rd. With the late afternoon sunlit mountains as a backdrop, we caravanned about 1/3 mile to the first large field on the right in the cove and set up in the middle of the field. After setting up of our scopes the evening started with a spread of picnic food that took care of anyone who was in need of sustenance. SMAS VP Mike Littleton smoked a 22 lb turkey as well as pulled pork as the main entree. The temperature had been in the upper 50's with 10-15 mph winds and beautiful clear skies. As soon as the sun went behind the ridge the chill in the air began to sink in as the temperature dropped. We had 15 telescopes and plenty of astronomers with family on hand, ready to answer questions and show views of the night sky. By 6:30 we wrapped up the picnic and had moved our vehicles to the bottom of the field, making room for the arrival of the star gazers. On que, at 7:30 ranger Mike Maslona walked the group down Cades Cove Loop Rd to our field. The group sat on a hillside at the edge of the field as the ranger gave them an orientation on what to expect. As, it was not yet completely dark, the scopes were trained on Jupiter for the first target. As darkness fell, M-42 (Orion Nebula) became the go-to target. Also, M-81, M-82, M-44 (the Beehive), M-31 (Andromeda Galaxy) and M-1 (Crab Nebula). As is usually the case with a planned public star party we had a curtain of clouds roll in at 8:00 making sucker hole viewing necessary for about an hour. With a little patience and a Go-To scope I was able to move the scope around to clear patches in the sky and kept offering "mostly clear" views of the stars and DSO's. No one seemed to mind. With many of the visitors it was their first time looking through a telescope. They were pleased with whatever we offered to show them. Owen Hoffman was the MC for the night, making his way around the crowd with a PA, microphone and laser pointer keeping the crowd entertained and informed. According to park ranger Mike Maslona there were 277 visitors at the event with 10-15 people lined up at my scope through most of the evening. I met people from all walks of life and all levels of interest in astronomy. I handed out club cards to around a dozen people who showed a high level of interest in taking astronomy to the next level. With any star party I attend, nothing gives me more satisfaction than to have a child climb up the step ladder to the eye piece of my scope and peek in for their first look at the night sky. To see look on their face as they look back at their parents and say "that is soooo cool!" makes the entire night worth the effort. As was the case with me, hopefully that "first look" will create a life long memory for a child. Maybe even motivate them to study hard and make a contribution to science later in life. I'll never know! The crowd thinned out and we broke down at 10:30 and caravanned back out of the cove by 11:00. I made my way back home, taking the Foothills parkway as a "shortcut" while listening to the music of Dave Luxton and Jonn Serrie. It was an enjoyable evening from beginning to end. If it were my full time job, nothing would make me happier.

(Editor's note: This is a wonderful outreach event and all ORIONites should plan to attend. Unfortunately conflicts prevented many from attending since April 2 was a TAO night and a Pickett event. ORIONites present were Owen, Roger, and me.)

Astronomers setting up scopes for observing at the GSMSP

Southern Star Party- Roy Morrow

I attended the 30th Southern Star Party held at Wild Acres Resort in Little Switzerland, NC. This event sponsored by the Charlotte Amateur Astronomers Association is known for exceptional speakers, good food and lodge accommodations. This is the only star party my wife Margaret will attend since many years ago she adamantly refused to tent camp and eat camp food! The Southern Star is expensive costing ~$250 per person, but includes three nights accommodation, eight delicious meals and lots of door prizes. I have attended most every Southern Star for the past 20 years and made many long term friends.

Speakers:

Dr. David Devorkin is curator for the history of astronomy and space science at the Smithsonian's National Air and Space Museum and author of several books including the recently published "The Hubble Cosmos". His talks were "The Hubble Space Telescope's Greatest Moments" and "Searching for Planetary Companions to Stars Prior to the 1990's Explosion".

Jordan Evans is a senior project engineer for NASA's Jet Propulsion Lab (JPL). He gave an entertaining talk "Tales from the Clean room: Engineers Just Wanna Have Fun" detailing how humor tempers the tense operations testing components of the Webb Telescope in giant vacuum chambers. After all he said what can go wrong, it's just Rocket Science! His second presentation was "The Challenges of Building Telescopes for Outer Space and Other Worlds" The complexity and redundancy of the Webb Telescope requires massive effort to ensure it **WORKS**! Evans also described the next Mars rover that will "vaporize" rock samples and analyze the result with a robotic spectrograph. One of NASA's advanced programs for direct imaging of extrasolar planets is "Starshield". The concept there is to unfurl a massive Mylar shield many miles ahead of the imaging craft. This shield will be positioned to block the star light allowing planets to be directly imaged.

Dr. Hank Greenberg is recently retired from the University of Arizona's Lunar and Planetary Lab and now lives in Charlotte. His keynote address was "Unmasking Europa: The Search for Life on Jupiter's Ocean Moon" Using data from Voyager and Galileo spacecraft his group showed how the massive ice ridge systems evolved and how future landers may drill through the thick ice to sample the underlying

ocean for life forms. Europa's ice ridges and valleys seem to arise through "tectonic" activity similar to mountain and valley formation on the earth's crust. There are indeed heat sources in Europa's core.

Dr. Chris Richardson leads the astrophysics research group at Elon University. This relatively small school of 8,000 students offers a major in Physics with a minor in astronomy. Richardson works with others using the Kepler telescope to identify extrasolar planets. His main area of research is understanding the nature of extreme star forming galaxies. The research focuses on using simulations to recreate the conditions necessary to produce the observations form star forming galaxies.

Several attendees bring telescopes and this year Vic Menard shared his 24 in. Star Structure dobsonian on the one clear dark night of the event. WOW under the dark skies one can see the spiral arms and connecting lane of M51 and M3 looked like a celestial fireworks explosion!

ORION President's Perspective for April 2016 David Fields

Breakthrough Initiatives from Hawking and Milner. Local Stargazes

The (mostly) radio-astronomy based Search for Extraterrestrial Intelligence (SETI) was stimulating a lot of forward-thinking and research until politician Proxmire made it politically verboten in 1982. Until then, it was a serious part of radio astronomy, stimulating research and instrumentation development.

Now a $100Million infusion of funds, "Breakthrough Listen", with guidance from Stephen Hawking and money from Yuri Milner has stimulated thought and action, with new data being taken at the Green Bank NRAO facility and Lick Observatory[1].

Figure 1 The Parkes radio telescope is another resource that will contribute to the Hawking/Milner "Breakthrough Listen" initiative[2].

[1] http://www.gizmag.com/breakthrough-listen-search-et/42794/?utm_source=Gizmag+Subscribers&utm_campaign=99063d2560-UA-2235360-4&utm_medium=email&utm_term=0_65b67362bd-99063d2560-91135181

These data are now publically available[3] for examination and research.
A second Breakthrough Initiative, "Breakthrough StarShot" was announced on April 12, 2016. This second infusion of $100Million is directed to funding development of LASER-driven photon-propelled spacecraft. The biggest name in the LASDR-driven photon-propelled spacecraft field is Phil Lubin, who spoke at the TVIW conference held at the end of March in Chattanooga. I had a conversation with him there.

Phil is in addition, a member of the Hawking/Milner advisory team for Breakthrough Listen. Also at the TVIW conference were Kelvin Long of I4IS, Jim Benford of UC and Geoff Landis of NASA, advisors to the Hawking/Milner team. Another member of that 25-member board, is Greg Matloff, who attended TVIW. He is in fact a founder of TVIW. Another advisor, (Astronaut) Mae Jemison, was scheduled to speak at the Oak Ridge TVIW. So we are not so far removed from these ground-breaking initiatives. Astronomy is moving ahead!

Figure 2 Shown here (LEFT) is a photo of (from left) me, Phil Lubin (UC), Geoff Landis (NASA) and Angelo Genovesse (Director I4IS Experimental Programs).

Bogdan Vacaliuc and I contributed to this conference with a poster, **Radio Astronomy Adaptive Technology for the Interstellar Age**, about interstellar communication and how computer-interfaced decision-making would be necessary. It introduced RASDR, a collaborative project involving several creative people, most of whom I managed to list as co-authors.

Bogdan also attended the SARA western conference on March 12 at Embry-Riddle Aeronautical University in Prescott, AZ and presented a poster "Announcing RASDR3". He also presented a Powerpoint to the Prescott attendees, which covered RASDR history, testing, and design.
Photos from the conferences show the posters, which stimulated several discussions.

[2] http://www.gizmag.com/breakthrough-initiatives-search-intelligent-life/38570/
[3] http://www.breakthroughinitiatives.org/OpenDataSearch

Figure 3 Photos from the conferences show (L) David with the Chattanooga poster and (R) Jay Wilson and Bogdan with the Prescott poster

Finally, let's see what we might do for local Stargazes: I've done a survey of light pollution at 10 Oak Ridge sites, and will publish this in the May Trapezium. Looking ahead, Grove Center is OK – provided we can douse some of the street lights, or rise above them. You'll have to read next month's Trapezium to learn about these implications.

Scientific, Philosophical and Artistic Reflections on Black Holes

By John C. Mannone

When thinking about black holes, there is both interesting physics and imagination.

John Michell, a contemporary and associate of Henry Cavendish, is the first documented person to think about black holes (a term coined by John Wheeler in 1967). In 1783 he imagined stellar objects whose gravity were so strong that the escape velocity would be that of light, thus "dark stars" [1]. Pierre-Simon Laplace independently promoted the same concept in 1796. Both were predicated on classical Newtonian physics and treating light as particles (corpuscular theory). So an object orbiting a central mass, M, with orbital radius, R, would remain gravitationally bound unless it travels fast enough to escape. From the balance of gravitational and centripetal forces, the typical escape velocity is derived as

$$\frac{\quad}{\quad}$$

where G is the universal gravitational constant ($G = 6.674 \times 10^{-11}\ m^3kg^{-1}sec^{-1}$).

For example, the escape velocity for Earth is about 25,000 miles/hr. But can this formulation be applied to light? No. Despite the fact that Albert Einstein proved in 1905 (for which he received the Nobel Prize; i.e., for the photoelectric effect) that light is comprised of energy packets called photons—which can be thought of as massless particles—the derivation of the above equation requires the cancellation of particle mass. Of course, a massless particle leads to division by zero, which is not allowed.

However, a classical approach may still be used via the conservation of energy and the realization that mass and energy are interchangeable (another 1905 Einstein contribution, $E = mc^2$). Balancing kinetic and gravitational potential energies and taking the limit as v approaches c leads one to the same result

Karl Schwarzschild obtained in 1916 when he solved Einstein's General Relativity equations to determine the radius of a black hole—the Schwarzschild radius, R_S [2],

$$R_S = \frac{2GM}{c^2}$$

We often think of black holes as very massive objects [3]. When a sufficiently massive star undergoes a supernova explosion, the resulting black hole may be 3-30 solar masses. There are intermediate black holes in the order of 100 or 1000 solar masses that might be in the center of various star clusters. Then there are the supermassive black holes at the center of galaxies in the order of millions or billions solar masses (and they may be accompanied by a bunch of smaller ones). Our own Milky Way has a 3.8 million solar mass black hole in Sagittarius when viewed from Earth.

But Schwarzschild's derivation implies *any* object could be a black hole. Imagine Earth. It would become a black hole if it were compressed to it Schwarzschild radius. Using Earth's mass (5.97×10^{24} kg), one can calculate R_S to be 8.86 mm, about the size of an average glass marble (10 mm). See Figure 1.

Figure 1. Earth as a glass marble (Picture courtesy: West End Collectables)

According to General Relativity [4], any mass would deform spacetime, rendering gravity as a geometric effect and not a force as in Newton's physics. This is accurately represented in the Figure 2 below [5].

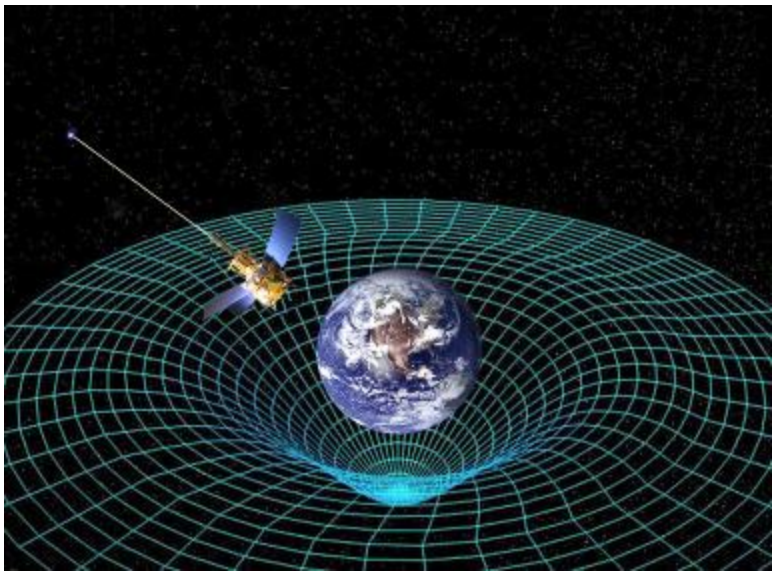

Figure 2. Einstein's theory of general relativity predicted that the space-time around Earth would be not only warped but also twisted by the planet's rotation. Gravity Probe B showed this to be correct. (*Credit: NAS*)

But as Earth is shrunk, the depression in spacetime would be driven to a "singularity."

A similar calculation can be done for the Sun, and its mass (1.989×10^{30} kg) would require a Schwarzschild radius of 2.95 km. Even though it would be impossible for our Sun to become a black hole (it has insufficient mass to supernova; it will eventually intumesce to a red giant and leave an embering white dwarf and a planetary nebula), it is still fun to imagine if it were to become one. We often dispel fear by correctly saying that Earth's orbit would be unaffected (but the ensuing darkness would plummet us into an irreconcilable deep freeze). However, if our Sun could become a black hole, the solar system dynamics might considerably change because of additional conservation laws:

(1) The conservation of angular momentum ($\Lambda = I\omega$ = constant) leads to a rotation of the black hole sun of once every 46.5 microseconds if my calculations are correct, which means it is spinning at relativistic speeds, $\beta = v/c = 0.45$, at the event horizon. This could present problems for nearby planets as accelerated charged particles near the black hole radiate energy in the plane of the orbit and therefore of the planets.

(2) The conservation of magnetic flux lines ($\Phi = BA$ = constant), sometimes stated by as flux lines frozen in plasma. Alfvén's Theorem [6] will lead to a great intensification of magnetic fields comparable to neutron stars. I calculated nearly 300 million Tesla.

One more thought about the size of black holes: microscopic ones [7] have been theorized. The Kaluza-Klein Theory [8] is a mathematical extension of General Relativity to the 5th spacetime dimension in an effort to unify gravity with the electromagnetic force. Some hypothesize that the extra dimension allows microscopic black holes (quantum mechanical black holes) to be formed at TeV energies available in particle accelerators. However, these Planck mass black holes (22 micrograms) are believed to quickly evaporate (emitting Hawking Radiation) and not coalesce into large, existence-threatening black holes.

But it is fun to speculate what if that were not the case and that the black holes grew into "monsters" consuming everything around it. A science fiction flash piece, "Golden Apples" [9] entertains that conjecture when the Large Hadron Collider was gearing up for the search for the Higgs Boson.

It is the "singularity" from solving the General Relativity equations that must be reconciled by combining this remarkable theory of gravitation with Quantum Mechanics, which yields Quantum Gravity [10]. That's what String Theory [11] is all about: "The general theory of relativity is formulated within the framework of classical physics, whereas the other fundamental forces are described within the framework of quantum mechanics. A quantum theory of gravity is needed in order to reconcile general relativity with the principles of quantum mechanics, but difficulties arise when one attempts to apply the usual prescriptions of quantum theory to the force of gravity." And though it has some redeeming features, it seems it too has failed. Here is the overview of where quantum gravity would fit in the hierarchy of physics. See Figure 3.

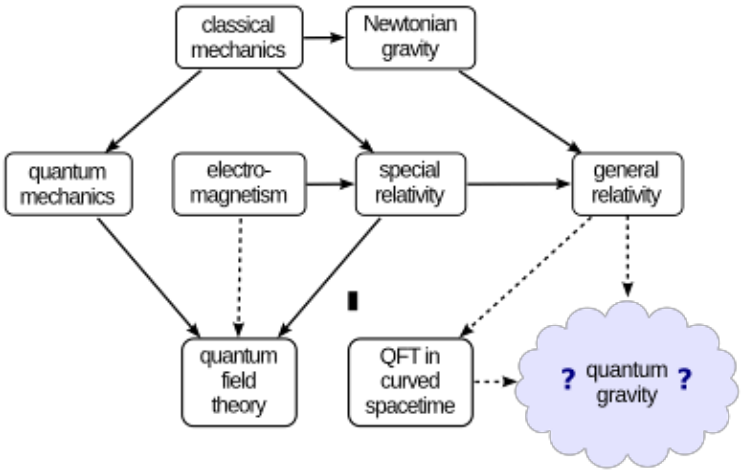

Figure 3: Where does quantum gravity fit in the hierarchy of physics? (*Diagram courtesy: B. Jankuloski*)

Here are some departing, and very speculative thoughts for which I credit poetry to having opened my mind—the left-brain—conditioning me to think outside the box.

In short, I posit that all 4 intrinsic quantities—matter, energy, space, time—are unified as some degenerate structure at the black hole "singularity." But some of these are already connected: Matter and energy are unified via Einstein's remarkable equation, $E = mc^2$. This relation has connections to Quantum Mechanics [12]. Note also that space and time are unified to spacetime via Einstein's relativity and Minkowski's 4-vector [13], which treats time as an imaginary spatial coordinate. So it is reasonable to imagine that all four quantities are united, which in turn could be just the architecture necessary to unify Quantum Mechanics with General Relativity. I can imagine those quantum mechanical black holes mentioned earlier inducing quantum fluctuations as they merge, not in the 5^{th} dimension where we have seen them evaporate, but in a higher dimension where they might merge to some extent because the strength of gravity might increase in those higher dimensions [14]. It seems that unified field theories using the necessary algebras, fields and groups will make the connections.

Though some of these ideas came to me 15 years ago, only recently have I been able to articulate them. I will safely leave them in the world of speculative science in contradistinction to science fiction, but this is not science fact either. I leave it to someone else to do the mathematics and formulate a mathematical hypothesis, which sadly far exceeds my capabilities at this moment despite the fact that equations are poetry to me... I have been known to cry at their beauty.

Ironically, another poet, Edgar Allan Poe, had insights (indirectly) to General Relativity before it was even formulated when he explained why night sky is dark and not ablaze with light [15]. My conjecture is perhaps naïve, but even at this conceptual level, who knows, it might stimulate some bright young physicist. If I'm right, it would be another kick (in a good way) for the poet, but if I'm wrong, poetic license will save me the embarrassment.

I recently discovered the *Mad Scientist Journal* [16] where one might express such ideas in a creative way.

Footnotes

1. John Michell 1783 "dark star"
https://www.aps.org/publications/apsnews/200911/physicshistory.cfm
https://en.wikipedia.org/wiki/John_Michell
2. Schwartzchild radius
https://en.wikipedia.org/wiki/Schwarzschild_radius
3. Black Holes
http://science.nasa.gov/astrophysics/focus-areas/black-holes/
4. General Relkativity
https://en.wikipedia.org/wiki/General_relativity
5. *Einstein's Theory of General Relativity*, Nola Taylor Redd (Space.com), February 11, 2016
http://www.space.com/17661-theory-general-relativity.html
6. Alfvén's Theorem
https://en.wikipedia.org/wiki/Alfv%C3%A9n%27s_Theorem
http://www.sp.ph.imperial.ac.uk/~mkd/Handout4.pdf
The Physics of Strong Magnetic Fields in Neutron Stars, Qiu-he Peng, Hao Tong
http://arxiv.org/pdf/0706.0060.pdf
7. Micro black holes
https://en.wikipedia.org/wiki/Micro_black_hole
8. Kaluza-Klein Theory
https://en.wikipedia.org/wiki/Kaluza%E2%80%93Klein_theory
9. "Golden Apples," John C. Mannone, *Quantum Shorts*, November 2013
http://shorts2013.quantumlah.org/entry/golden-apples
Possibility of Catastrophic Black Hole Growth in the Warped Brane-World Scenario at the LHC, Roberto Casadio, Sergio Fabi, Benjamin Harms
http://arxiv.org/pdf/0901.2948.pdf
10. Quantum Gravity
https://en.wikipedia.org/wiki/Quantum_gravity
11. String Theory and Eleven dimensions
https://en.wikipedia.org/wiki/String_theory
12. Encyclopedia Britannica Blog http://blogs.britannica.com/2010/09/e-mc2-the-unforgettable-equation-of-einsteins-miracle-year-picture-essay-of-the-day/

13. Minkowski's Spacetime
https://en.wikipedia.org/wiki/Minkowski_space
14. Gravity in higher dimensions and a new theory for strong gravity
http://home.uni-leipzig.de/tet/?page_id=87
http://home.uni-leipzig.de/tet/?page_id=786
http://www2.lbl.gov/Science-Articles/Archive/multi-d-universe.html
15. Edgar Allan Poe who helped solve the long-standing physics problem conceptually by explaining why the night sky is black and not ablaze with light (Olbers' Paradox). His intuition was consistent with the formal explanation 70 years later when Einstein formulated one of the most successful theories in physics—General Relativity.
http://www.amnh.org/education/resources/rfl/web/essaybooks/cosmic/cs_paradox.htm
16. *Mad Scientist*
Journal

ORION is an amateur science and astronomy club centered in Oak Ridge, TN that was founded in April 1974 by a group of scientists at the United States Department of Energy facility in Oak Ridge, Tennessee. We serve Oak Ridge, Knoxville, and the counties of Anderson, Knox, and Roane.

ORION's mission is to support science research, teaching, and amateur astronomy in East Tennessee, and therefore we are closely associated with and support TAO by volunteering to host their public events, share our knowledge of the skies with a variety of telescopes, and help provide intellectually stimulating programs at the observatory. ORION works to share the wonders of the cosmos and the culture of science to people from all walks of life.

Members are scientists, engineers, technicians, and others with varied talents and expertise. Over half have telescopes, many are amateur radio operators, and some have a technical interest in astrophotography.

ORION has working relationships with several organizations, including museums and amateur astronomy groups. Membership is open to individuals who will actively contribute their time and ideas. Our annual membership dues are $20.00 and student discounts are available.