A1: GLOSSARY OF SCIENTIFIC TERMS

The following includes basic explanations of scientific concepts mentioned in this story. Most of these reflect the accepted wisdom. Several relate to newer models and recent research, some of which do not accord with traditional approaches. (These will be distinguished below, with sources provided.)

Terms that appear in **bold** *represent other entries in this Glossary.*

0.15c: "Zero point one five C." This represents 15% of the **speed of light** (represented by the letter 'c'), or 0.15 times the speed of light. That is a speed of about 45,000 km per second, a speed at which you could circle the globe at the equator in less than a second.

0.9988c: "Zero point ninety nine eighty eight C." This represents 99.88% of the **speed of light** (c), or 0.9988 times the speed of light. That is a speed of almost 300,000 km per second, a speed at which you could get to the moon in just over a second.

0-G: (*see* **Zero-G**)

1-G: A gravitational force (or a force due to acceleration) that is equal to the strength of Earth's **gravity** (represented by the letter 'G').[2] The acceleration due to gravity on Earth is 9.8 meters per square second (m/s^2), so someone will experience a 1-G force when they are on Earth or when they are in a rocket that is burning fuel to accelerate at 9.8 m/s^2. 1-G propulsion occurs when a spacecraft accelerates constantly at 9.8 m/s^2 for

[2] A recent theory proposing both an explanation of and an actual mechanism for gravity is described below. (*see* **Gravity**)

the first half of the journey (which requires a constant engine burn), during which its velocity is continually increasing. At the half-way point, the craft cuts its engines and flips 180° to place its rear thrusters in the direction of travel, and then burns its engines again with the same thrust as before in order to decelerate (–9.8 m/s^2) for the second half of the journey (which also requires a constant engine burn), during which its velocity is continually decreasing. That way, travelers experience the comfort of 1-G for the entire journey, except for the weightlessness (*see* **Zero-G**) they will experience during the half-way flip. 1-G propulsion is obviously an extremely fuel-intensive prospect and will only be feasible when abundant energy (or fuel capacity) is available for propulsion.

7-G: A force seven times stronger that Earth's **gravity** acts upon a body. This is either because the body is on a planet with a **mass** seven times larger than Earth, or because it is accelerating at 68.6 m/s^2, or because it is turning sharply at high speed, as fighter pilots often experience. Such high G-forces pose a significant danger to pilots of loss of consciousness, since blood is pushed to one side of the body preferentially, inhibiting proper circulation.

Alpha Centauri: The nearest star system to our solar system, and part of the **constellation** Centaurus. It is a three-star system containing two bright stars called Alpha Centauri and Beta Centauri that orbit one another — a binary star — and a third dimmer **red dwarf** star called **Proxima Centauri**. Proxima Centauri is the nearest of the three stars to us, at a distance of just under 4.25 **light years**. Several **exoplanets** have been discovered **orbiting** it. The innermost one, Proxima b, is in the star's **habitable zone**.

Angular momentum: Normal (linear) momentum is a term that refers to a combination of the **mass** and velocity of an object.[3] The larger the value, the more inertia the body possesses, and the more strongly it will resist a change in its speed or direction of motion. Angular momentum is the analogy of this for a body that is rotating or moving in a circular path.[4] Its inertia will similarly cause it to maintain that rotation and resist a change. A gyroscope is a classic example of this principle. Like **energy** and linear momentum, angular momentum must be conserved. This is one of the reasons that **nuclear reactions** eject (or absorb) **antimatter** particles. Since the normal matter particles produced in the reaction may not possess the same quantum **spin** (collectively) as the original particle, another particle must emerge with a spin that offsets the difference. This ensures that the overall angular momentum should be the same after the reaction as it was before. For a **quantum** system that has angular momentum, its energy can be expressed as a function of its angular momentum according to the equation $E=\hbar\omega$.

Antimatter (or **anti-particles**): A particle of matter has a corresponding antimatter particle, or antiparticle, which has the same **mass** but opposite electric **charge**. The positively charged **proton**'s anti-particle is the anti-proton, and it has the same mass as the proton but a negative charge. The anti-particle of the **electron** is the **positron**, which has positive charge. While **neutrons** and **neutrinos** are electrically neutral, they still have anti-particles, called the anti-neutron and the anti-neutrino. In the case of the neutron, while it has no overall

[3] The equation for momentum (p) is $p=mv$, where m is the object's mass and v is its velocity.

[4] The equation for angular momentum (L) is $L=I\omega$, where I is the object's moment of inertia and ω is its angular velocity.

charge, it is comprised of (according to the standard model) quarks that have charge or (according to the **rotating photon model** of matter[5]) photon **harmonic** resonances that express either positive or negative electric fields. In the corresponding antiparticles, these resonances rotate in the opposite direction, yielding the opposite charge in charged particles but the same overall neutrality in neutral particles. According to this model, antimatter is matter that is composed of particles whose internal (**photon**) structure has opposite quantum '**spin**-handedness' (**chirality**[6]), and therefore, opposite electric charge. When a particle and its anti-particle meet, they unlock each other's internal spin **angular momenta**, converting their rotating photons to linear photons in a high-**energy** release called a matter-antimatter annihilation.[7] One of the famous problems in physics is explaining why the observable universe is filled almost entirely with normal matter but only a very small amount of antimatter. According to the standard model, the universe should contain them in equal proportions, and this remains a mystery known as the problem of baryonic asymmetry. According to observation, antimatter is only encountered in association with nuclear transmutation reactions. According to the **rotating photon model** of matter, antimatter *only* arises as a result of a **nuclear reaction** because that is the role it plays. Antimatter particles are the photon resonances that form (and are consumed) as part of nuclear transmutation reactions, specifically in order to conserve photon angular momentum (as well as other **quantum**

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[5] As proposed in the **Williamson-van der Mark** model of the electron and **sub-quantum mechanics**, as well as in the **Robinson Models** of Nuclear Binding and Quantum **Gravity**, referenced below.

[6] This refers to the orientation of a particle's **spin**, and it is designated as left-handed or right-handed. (*see* **Chirality**)

[7] See the image in the 'NOTE' at the beginning of the book, which represents this concept according to the **rotating photon model**.

numbers) through that reaction. These antimatter particles can then be consumed in other nuclear reactions or in annihilation reactions with matter particles. They will therefore not have long-term survivability in a universe made of regular matter, and their lack of (baryonic) symmetry is to be expected.

Atmosphere: The gases that surround a planet, held to it by **gravity**. This causes atmospheres to be denser nearer the surface and thinner at higher altitude (like on Mount Everest). The presence of a **magnetic** field helps to prevent a planet's atmosphere from being lost into space (*see* **magnetosphere**). The gases in the atmosphere protect the organisms on the surface by absorbing dangerous incoming radiation before it can reach the surface. Earth's atmosphere is made up of 78% nitrogen gas (N_2), 21% oxygen gas (O_2), and the remaining 1% contains a mixture of other gases including carbon dioxide (CO_2) and water vapor (H_2O). The densest part of Earth's atmosphere, in which just about all weather occurs, is called the troposphere, and it stretches from the ground up to an altitude of about 12km. In simple terms, the outermost part of the atmosphere reaches out to about 100km, but technically, it actually extends much further out and has no clear or sharp boundary. Beyond 100km, though, its density is extremely low.

Atom: The smallest particle of a pure **element**. When two or more atoms are bonded together it is called a **molecule**. When **ions** or metal atoms bond together, they form a crystal. All solids, liquids, and gases are made of atoms or molecules. An atom contains a nucleus, a tiny positively **charged** central region containing **protons** and **neutrons**, which contains just about all of the **mass** of the atom. This is surrounded by an **electron** cloud, a region of negative charge that fills the space around the nucleus. The positive charge field of the nucleus is thus cancelled by the negative charge field of the electron cloud around it. The charges are therefore balanced and their electric field **energy** is neutralized, which stabilizes the atom by putting it into a lower energy state. Protons, neutrons, and electrons are known as subatomic particles.

Aurora: A portion of the **atmosphere** above the pole of a planet glows with a dancing light display. It is caused when energetic particles arriving at the planet strike **molecules** in the atmosphere, causing them to luminesce. It occurs above the polar regions because the incoming **charged** particles spiral along the planet's **magnetic** field lines, and these are near-vertical at the poles. This directs the charged particles arriving near the poles downwards and into the atmosphere. The effect is very similar to a glow discharge tube, which also involves electric current (a flow of charges) discharging through a low density gas.

Ayahuasca: An ancient South American shamanistic brewed tea with hallucinogenic effects. It is used to enter an altered state of consciousness for the purposes of meditation, introspection, or healing.

Bends: (*see* **Decompression sickness**)

Big Bang: According to the standard model of cosmology, the universe began in an intense explosion of **energy** that arose from a tiny point — a singularity. That energy then cooled as it expanded, coalescing into subatomic particles, which combined to form **atoms**, which clustered together under the force of **gravity** to form stars and planets, and thus, the cosmos as we know it today. Evidence supporting this idea is taken from the fact that starlight is **redshifted**, which is interpreted to mean a **Doppler** shift is occurring, which would mean that almost all of the stars and galaxies in the universe are moving apart from one another. When this concept is projected backwards in **time**, it eventually reaches a situation where all matter in the universe is concentrated at a tiny point. Additional support is taken from the existence of a cosmic microwave background radiation, a pervasive 'static' of low-energy **photons** that appears to fill the universe. This is believed to be the cooled, remnant energy from that initial explosion, now at a frigid **temperature** of 2.7K (or –270.5°C or –454.8°F). However, there are those who contend that there are other possible explanations for both **redshift** and the microwave background.[8,9] These do not require a Big-Bang type event, in which the laws of physics as we know them cease to apply. Given its many challenges, there are many who believe it is time to set this theory aside.

Birkeland current: An electric current flow through a **plasma**, such as in Earth's ionosphere. It is also known as a field-aligned current since the flow of **ions** tends to follow (and spiral around) the **magnetic** field lines of the planet. Birkeland currents have also been observed in space plasmas. They are named after the Norwegian physicist, Kristian Birkeland, who explained the **aurora** borealis phenomenon.

Blueshift: When a light source is approaching, either because we are moving towards it or it is moving towards us, then its light waves appear squashed or contracted. This gives the appearance of a shorter **wavelength** and therefore a higher **frequency** for the waves. When this involves visible light waves, it means the color of the light is shifted towards the blue (higher frequency) end of the rainbow, hence the name.

Brunton pocket transit: Also known as a Brunton compass. It is a specialized compass used in several fields, but in geology, it is

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[8] *See* Vivian N. E. Robinson, *How to Build a Universe: Beyond the standard models*, ETP Semra (2021), Chapter 11, ISBN-13: 978-0645412512
See also Eric J. Lerner, *The Big Bang Never Happened*, Vintage Books (1992), ISBN 13: 9780679740490

[9] *See* https://quicycle.com/breakthroughs/ *for more detail.*

used to take accurate measurements of 'strike and dip,' the angles and directions of rock formations.

Cambrian period: A geological period on Earth from about 539 million years ago to about 485 million years ago. It constitutes the first part of the **Paleozoic era**, and is characterized by the rise of multicellular organisms.

Celsius: (*see* **Kelvin**)

Charge: A particle manifests an electric charge if there is an imbalance between the positive and negative electric field that it is projecting into the space around it. According to the **Williamson-van der Mark model**[10] of the **electron**, its substructure — the toroidal shape traced by the **photon** that makes up the electron — keeps the negative polarity of the photon's electric field pointing outwards at all times. That results in its monopole negative charge. In the case of the **proton** or **positron**, the positive polarity of the inner photon's electric field is pointing outwards. That results in its monopole positive charge. When a photon of light is traveling in a straight line, it has no charge because its electric field is waving back an forth between positive and negative polarity (in the case of a plane-polarized photon) or spiraling around its axis of travel (in the case of a circularly-polarized photon), both of which average the overall charge to zero.

Chemosynthesis: In conditions where **photosynthesis** is not possible or feasible — for example at a seismic vent along the ocean floor (where sunlight does not reach) — plants can produce their food energy using a different chemical process that does not involve sunlight. They mine the heat energy and

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[10] John G. Williamson, "A New Linear Theory Of Light And Matter," *Journal of Physics: Conference Series*. 1251. 012050 (2019).
See also www.Quicycle.com

hydrogen sulfide gas (H_2S) from the vent and use it to convert dissolved carbon dioxide (CO_2) and oxygen (O_2) gas in the water into sugar molecules ($C_6H_{12}O_6$).

Chirality: This refers to the orientation of a particle's **spin**, and it is designated as left-handed or right-handed because it is directly analogous to the difference between our perspective of our right hand versus our left hand. Consider a left hand curled into a fist but with the thumb extended in a 'thumbs-up' gesture. A left-handed chirality means, if the **magnetic** north pole of the particle is pointing in the direction of the left thumb, the particle is rotating or circulating in the direction of the curled up fingers. Looking down onto the north pole thumb, that would look like a clockwise circulation. A counter-clockwise rotation would therefore indicate a right-handed chirality, which is what a left-handed chirality looks like from the other side.

Constellation: A pattern of stars in the night sky, as viewed from Earth. There are dozens of these shapes. Most were named by ancient civilizations according to their myths and legends, and they include the twelve signs of the Zodiac. The stars in a particular constellation need not be close to one another at all. It is only our vantage point from Earth that groups them together. By way of example, one of the stars in the constellation Centaurus is **Alpha Centauri**, 4.3 **light years** from Earth. Another star in the same constellation, Theta Centauri, is almost 59 light years from Earth. Another, Gamma Centauri, is 130 light years away, and another, R Centauri, is over 1,200 light years away. As is true of most constellations there are many stars that are a lot closer to Alpha Centauri than the other stars in its constellation.

Cosmic rays: These are not really 'rays' but atomic particles, usually with a positive **charge**. They are emitted, for example, when stars explode in **supernovae**, and they travel at very high speeds and carry high **energy**, making them dangerous. About 90% of them are hydrogen **ions** (i.e. **protons**), about 9% are helium ions (alpha particles), and the remaining 1% are ions of various other **elements**. While Earth's **magnetosphere** protects us from many of them by deflecting them around the planet, in space they pose a danger to both living organisms and equipment.

Decompression sickness (DCS): When gas **molecules** come into contact with the surface of a liquid, some of them dissolve into the liquid as they collide with it. The higher the **pressure**, the more frequent the collisions and the more gas will dissolve. If pressure is then suddenly decreased, the liquid is no longer forced to hold as much gas, and excess gas now bubbles out of solution. This depressurizing can happen when a bottle of carbonated beverage is opened, when a diver swims back towards the water's surface, or when an astronaut is exposed to a very low pressure (or vacuum) environment. In addition, a rapid decrease in pressure causes gas volumes to expand. If the lungs are full of air and the breath is held, this expansion risks rupturing the alveoli (air sacs) in the lungs, which would introduce air into body tissues and blood vessels. Whether from a rupture or from gas bubbling out of solution, air bubbles in the bloodstream can pose very serious health risks. They can block blood vessels, causing a host of symptoms ranging from joint pain to stroke, paralysis, and death. Decompression sickness is usually treated by returning the patient to the higher pressure (in a decompression chamber) in order to redissolve the gas bubbles in their system. They are then brought back to normal pressure gradually enough to avoid the formation of gas bubbles.

Doppler effect: The Doppler effect occurs when a wave source is either getting further away — because we are moving away from it or it is moving away from us, or getting closer — because we are moving towards it, or it is moving towards us. When this occurs with sound waves, the pitch (or **frequency**) of the waves appears to increase as it approaches and appears to decrease as it moves away. A typical example might be a passing ambulance or police siren. This is only a perceived effect, though, due to the relative motion of the source and the observer. The siren is not actually changing its pitch. When it occurs with light waves, the waves are redshifted as the source moves away from the observer and blueshifted as the source approaches the observer (*see* **Redshift** *and* **Blueshift**). This change in color is analogous to the change in pitch for sound waves, since it results from a stretching or contraction of the **wavelength**.

DNA: DNA stands for *deoxyribonucleic acid*. It is a very long **molecule** in the shape of a double helix, a (polymer) chain made up of many individual building-block molecules called nucleotides. There are four different nucleotides present in DNA, known by the first letter of their molecular names — Adenine (A), Thymine (T), Guanine (G), and Cytosine (C). Our genetic information is carried in the order of these nucleotides in the double helix. In most living organisms, DNA is stored inside the nucleus of each cell. It is the DNA code that determines not only the structure but the function of living organisms. It determines, for example, the types of **proteins** that the cell will manufacture, as well as where and how these proteins will be used in the body. According to the concept of evolution, the DNA of all species on Earth should be able to trace its heritage back to the same original code. Humans have been experimenting with genetic manipulation through cross-breeding for as long as we have been an agricultural species. Technologies that allow us to manipulate and wield the power of DNA continue to evolve, promising ever-increasing opportunities for humans to cure disease and direct the course of our own biological evolution. Examples of these technologies include the Nobel Prize-winning CRISPR technology and the invention of synthetic nucleotides and unnatural base pairs[11,12].

E=mc^2: This is Einstein's famous formula that relates **energy** *(E)* to **mass** *(m)*, using the square of the **speed of light** *(c^2)* as the ratio (or conversion factor) between them. Radiant energy and matter are really two forms of the same **root-energy** 'stuff.' If we want to know how much pure energy we get if we convert matter into pure radiant energy, we multiply its mass by the speed of light squared, which is a very large number (9×10^{16}). It also reflects the fact that, according to both the **Williamson-van der Mark** Model and the **Robinson Model**, particles that have mass, such as **electrons**, are really **photons** of light that are traveling in a circle (or knot) rather than in a straight line. Such concentrated, self-sustaining photon **resonance** structures are the essence of matter.

Ecliptic: The disc shape or 'equatorial plane' in which planets and asteroids **orbit** around their star, or in which rings orbit around a planet. The ecliptic plane lies perpendicular to the axis of rotation of the system. In our solar system, while the planets and most asteroids orbit in the plane of the ecliptic, this rotating disc is not necessarily thin. The asteroid belt is actually as thick as the distance from the Earth to the Sun (1 AU, about 150 million km). In most **galaxies**, the central region of stars also tends to bulge out above and below the ecliptic.

Electric charge: (*see* **charge**)

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[11] Yorke Zhang, et.al., "A semisynthetic organism engineered for the stable expansion of the genetic alphabet," PNAS February 7, 2017 114 (6) 1317-1322.

[12] Hirao I, Kimoto M., "Unnatural base pair systems toward the expansion of the genetic alphabet in the central dogma," *Proc Jpn Acad Ser B Phys Biol Sci*. 2012;88(7):345-367.

Electric permittivity (ε_0): (*see* **spacetime**)

Electromagnetic radiation: The scientific term for light waves, whether they are in the visible part of the spectrum (like the colors of the rainbow) or the invisible part of the spectrum (for example radio waves or gamma rays). Light waves store part of their **energy** in an electric field and part of it in a magnetic field, hence the name. In a typical circularly-polarized **photon**, the electric and magnetic fields spiral around the axis of travel, 90 degrees apart (or out of phase with one another). Since an electric field incites a forward motion, like velocity, and magnetic field incites a rotation (see **spacetime**), the combination of the two should yield a combined electromagnetic field that spirals as it moves forward. Electromagnetic waves can only travel at the **speed of light** *(c)*, which is just under 300,000 kilometers per second. Like most waves, they have a wavelength (λ) and a frequency (ν), and the mathematical relationship between these three properties is given by the equation $c=\lambda\nu$. This implies that the larger the frequency, the smaller the wavelength, and vice versa, because the speed of light *(c)* must remain unchanged. The amount of energy carried by an electromagnetic wave depends on its frequency. This is reflected in Planck's equation for energy, $E=h\nu$, which indicates that the higher the frequency *(ν)* of the wave, the more energy *(E)* it carries. The ratio between energy and frequency is given by Planck's constant *(h)* (where $h=6.626\text{x}10^{-34}\ m^2kg/s$). High frequency waves, such as ultraviolet waves, are more dangerous than low frequency waves, such as radio waves, because UV waves carry much more energy. They can therefore **ionize** molecules, disrupt cellular function, or cause radiation burns. From lowest energy to highest, the main types of electromagnetic radiation are: radio, microwave, infrared, visible (red/orange/yellow/green/blue/indigo/violet), ultraviolet, X-ray, gamma ray.

Electromagnetism: The study of the interactions of electrically **charged** particles, as well as the interactions between electric fields, **magnetic** fields, and **electromagnetic radiation**. The field was pioneered by Michael Faraday and James Clerk Maxwell.

Electron: One of the three subatomic particles out of which all **atoms** are made. (The other two are the **proton** and the **neutron**.) An electron is negatively **charged** and highly stable. Contrary to popular misconception, it is not a point particle[13] but it has a sub-structure that gives rise to its properties. According to (the absolutely relativistic **sub-quantum mechanics** of) the **Williamson-van der Mark Model**[14,15,16] and the **Robinson Model**[17], an electron is made of a single **photon** of light making two revolutions per wavelength. An electron-positron pair is formed when two photons of the appropriate **energy** are condensed, forming two particles. One of the resulting double-loops, with its electric field pointing outwards, will have a positive charge — the **positron**, and the other, with its electric field pointing inwards, will have a

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[13] *See* https://quicycle.com/video/qv0047-john-g-williamson-misconception-1-the-size-of-the-electron/

[14] John G. Williamson, Martin B. van der Mark, "Is the electron a photon with toroidal topology?" *Annales de la Fondation Louis de Broglie*. 22. 133. (1997)

[15] *See* John G. Williamson (2019).
See also www.Quicycle.com

[16] Martin B. van der Mark, "Quantum particle, light clock or heavy beat box?" Journal of Physics: Conference Series; Bristol Vol. 1251, Iss. 1, (Jun 2019). DOI:10.1088/1742-6596/1251/1/012049

[17] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021)

negative charge — the electron. Similarly, when an electron and a positron interact, they unlock each other's **angular momenta**, releasing the once-confined photons as radiation in a matter-**antimatter** annihilation.[18] (This is *not* meant to imply that an electron can only form in a pair production event.) An electron is thus a self-confined knot of concentrated light energy traveling around itself at the speed of light. It has a toroidal (donut-shaped) sub-structure in (momentum) space, but the charge field of an isolated electron (or an *s*-orbital electron around a hydrogen or helium atom) manifests as a sphere. As a result of the geometry of this double-loop torus, the circularly-polarized photon's negative electric field is pointing outwards at all times, which is what gives the electron its negative charge. An electron has a left-handed **spin** of S=½, a charge of $C=-1.6\times10^{-19}$ Coulombs, and a **mass**-energy content of 511 keV.

Element: A unique, pure substance made up of only one type of **atom**. The number of **protons** in an atom's nucleus determines which element it is, and this is known as its atomic number. The periodic table[19] of the elements lists all 118 known elements in order of their atomic numbers. By way of example, the nuclei of all hydrogen atoms contain 1 proton, all helium nuclei contain two, and so on. The uranium atom has the heaviest naturally-occurring nucleus, and it contains 92 protons. All of the heavier nuclei, from atomic number 93 through 118, do not occur naturally and are created through the application of man-made nuclear technologies (like reactors, for example). They are all naturally unstable, and therefore, undergo **radioactive** decay.

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[18] See the image in the 'NOTE' at the beginning of the book, which presents this concept according to the rotating photon model of matter.

[19] *See* https://quicycle.com/periodic-table/

Energy: Energy is defined as the ability to do work or to transfer heat. The larger the amount of energy, the more work can be done (or heat transferred). Many different forms of energy propagate as waves, for example **electromagnetic** (light) energy or sound energy. The way that we refer to waves is therefore also the most convenient way to refer to energy. Energy (E) is most simply related to the **frequency** (ν) of its wave according to the Planck equation, $E=h\nu$. (Planck's constant h=6.626x10^{-34} m^2kg/s.) This indicates that the higher the frequency of a wave, the more energy it carries. The energy of movement, kinetic energy (E_k), is given by the equation $E_k=½mv^2$. This indicates that the larger the mass (m) or the higher the velocity (v), the more energy is carried. The average kinetic energy $(\tilde{E})$ of a gas particle is also related to its **temperature** (T) by the Boltzmann equation $\tilde{E}=1.5k_BT$. (The Boltzmann's constant k_B=1.380649×10^{-23} J/K.) This indicates that the higher the temperature, the more energy is present.

Exoplanet: A planet **orbiting** a star other than our Sun. Exoplanets are named by adding letters to the name of the star they orbit, starting with 'b,' since the star is considered to be 'a.' **Proxima Centauri** has more than one exoplanet orbiting it, and they are therefore named *Proxima b*, *Proxima c*, and so on. Earth is the third planet from the Sun, so according to this naming method, Earth would be called *Sun d*, because Mercury is *Sun b*, Venus is *Sun c*, Mars is *Sun e*, and so on. There are around 100 identified exoplanets within 32.6 **light years** (10 **parsecs**) of Earth. Exoplanets are considered favorable candidates for exploration if they exist in their star's **habitable zone**, which means they may be able to sustain life, and if their gravity is not too large.

Fever: Normal human body **temperature** is 36.9°C (or 98°F) because that is the temperature that best supports the body's biochemistry. While there is a range of opinions, a temperature of just over 38°C (or 101°F) is considered a fever. When the body develops a fever, it is using an elevated temperature to help fight an infection. This is not inherently a bad thing. Although many view the fever itself as part of the problem, it is actually part of the body's natural attempt at a solution.

Frequency (ν): The frequency of a wave is a measure of how frequently one passes a given point each second, or put another way, how many wave crests pass a given point each second. If two waves pass every second, the frequency is 2 (waves) "per second," also known as 2 Hertz (Hz). Frequency is measured in "per second," which means 1/*sec* (or s^{-1}). This means that frequency is the inverse (or reciprocal) of **time**, which is measured in *sec* (or s^1). Frequency represents **energy**. As reflected in the Planck equation, $E=h\nu$, the higher the frequency (ν) of an **electromagnetic** wave, the more energy (E) it carries. (Planck's constant $h = 6.626 \times 10^{-34}\ m^2 kg/s$.) High frequency Ultraviolet waves are more dangerous than low frequency radio waves because the UV waves carry much more energy. With electromagnetic (light) waves, when frequency (ν) increases, **wavelength** (λ) decreases, and vice versa. This is because the **speed of light** (c) is constant, and the three are related by the equation $c=\lambda\nu$. Frequency is also the means by which we measure time, whether the frequency of a pendulum, an atom, or a planetary orbit. Without frequency, i.e. energy, there is no time measurement.

Fungi: This is one of the six genetically distinct kingdoms of life on Earth, two of the others being *Animalia* and *Plantae*. Mushrooms, yeast, and mold are all types of fungi. It is estimated that there are somewhere between two and four million different fungal species on Earth, and they come in a great variety of forms and structures. Fungi have no chloroplasts for performing **photosynthesis**, so they have to gain their energy and nutrition from organic life that has already formed. They therefore play an extremely important role in the decomposition (and thus, the nutrient recycling) of living matter throughout nature. Some fungi produce substances that act as hallucinogenics, such as **psilocybin**. Some produce toxic substances known as **mycotoxins**. Some mushrooms are also considered to have properties that support a healthy immune system. Fungi can even digest a pile of toxic oil spill waste, gradually replacing it with natural plant growth.

Galaxy: A collection of millions to hundreds of billions of stars. Galaxies occur in several different shapes, for example globular clusters or spirals. Spiral galaxies have very similar 'Fibonacci' geometry to that seen in hurricanes and other natural spiral structures. Our galaxy, the Milky Way, is a barred spiral galaxy with a diameter of almost 200,000 **light years**, and is estimated to contain between 100 billion and 400 billion stars. Three quarters of these stars are believed to be **red dwarf** stars. The Milky Way itself is merely one among billions of other galaxies in the universe.

Ganymede: The largest planetary moon in our solar system. It is the third (and largest) of the four main (Galilean) moons of Jupiter. Of the four, Io and Europa orbit closer to Jupiter than Ganymede, and Callisto orbits further out. There are many other smaller satellites orbiting Jupiter, but their combined **masses** are very small in comparison to the Galilean moons. Ganymede is larger than the planet Mercury, making it the 9th largest object in the solar system, and it has an icy, crater-pocked crust. Its surface also receives large amounts of **radiation** from the planet Jupiter, enough to pose a risk to human health.

Geiger counter: A device that measures **radioactivity**. It usually makes an audible click sound each time a radioactive particle enters the detector. The faster the clicks are heard, the stronger the radioactivity in the vicinity.

Gravity (G): Gravity is a very weak force exerted by one **mass** upon another. (We could equally well describe mass as being a manifestation of the presence of a gravitational effect.) The force of gravity is approximately 10^{38} times weaker than **electromagnetism.** Isaac Newton's equation for gravity is:

$$F_N = \frac{GMm}{r^2}.$$

This equation describes that the force *(F)* of attraction exerted by one mass *(M)* upon another mass *(m)* gets weaker with (the square of the) distance *(r)* between them. (The gravitational constant G=$6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$.) According to Albert Einstein, gravity is caused by the fact that mass distorts **spacetime**. According to the Robinson Model of Quantum Gravity, the *mechanism* by which mass distorts spacetime is via the **redshift** of **photons**,[20,21] since matter is comprised of photons. Gravity is caused by a change in the refractive index of space, which is caused by the radial differential of the **electric permittivity** (ε) of space around mass. In turn, this is induced by the high frequency electric field oscillations resulting from the rotating photon structure of **protons** and **neutrons**. The high frequency nucleon oscillations add to produce a variation in electric permittivity that produces the same deflection for photons of all frequencies. This approach yields a *single,* simple equation of quantum gravity:

$$F_z = \frac{GMm}{r^2 e^{\frac{\alpha}{r}}}$$

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[20] Vivian N. E. Robinson, "Physical Explanations of Einstein's Gravity," *Journal of Physics Communications*, **5** 035013 (2021)

[21] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 9.

where α=2GM/c^2. This equation derives Newton's inverse square law as a first approximation, Einstein's field equations as a second approximation, and the bright torus-shaped accretion disc observed (at r=0.5α) around massive objects and galactic centers as an exact solution. As a consequence, *gravity is an* ***electromagnetic*** *effect*. When a very large mass distorts spacetime strongly, the force of gravity is weakened to slightly *less* than inverse-square. That is the reason the **orbit** of Mercury's perihelion precesses around the Sun in its direction of travel. (If gravity were stronger than inverse-square, such orbits would regress.[22])

Habitable zone: The range of distances from a star at which planetary **temperatures** would be survivable for human beings, and at which liquid water would be able to exist on the planet's surface — assuming it has the appropriate atmospheric conditions. This is because water is considered essential for the existence and sustenance of biological life. In our solar system, the habitable zone encompasses Venus at the hot end, Earth in the (ideal) center, and Mars at the cold end. The habitable zone around a small dim star (like **Proxima Centauri**) will be much closer to the star than around a much more powerful star (like our Sun). This will also make the planet's year much shorter.

Harmonic resonance: When an object vibrates or when waves interact, if their **frequencies** are multiples of one another then some of their nodes can overlap perfectly where they meet. The waves then reinforce each other and stabilize into a single symmetrical wave state. Such a harmonic resonance represents a lower **energy** state for a system since the waves can now share energy. They will therefore naturally seek out this state if they

[22] See also https://quicycle.com/breakthroughs/ as to why Schwarzschild's 'strong field' solution to an approximation in Einstein's general theory of relativity, taken out of context, is problematic and yields flawed results.

can. One example of a harmonic resonance would be the wave state set up on a guitar or a violin string when they are played, since multiple harmonics are sounding at different frequencies simultaneously with their waves superimposed along the string. Another harmonic resonance occurs when a wine glass is shattered by a sound wave whose frequency resonates perfectly with its interior volume. If the sound wave carries enough power, the vibrations it induces in the glass structure can destabilize it, causing it to crack or shatter. Subatomic particles like **protons** or **electrons** are also harmonic resonance states involving the rotating **photons** of various energies that make them up. Overall, **quantum** states can only be stable and coherent if they are in a state of harmonic resonance. Since there are no stable states between harmonics, it means that harmonic states will be intrinsically quantized.
Mathematically: 'Harmonic' means that the wave equations satisfy the double differential of themselves (where $\mathbf{\nabla}^2=0$).

Han Solo: (*see* **Parsec**.)

Hand lens: A small magnifying lens, similar to a jeweler's lens, that geologists use to look closely at the minerals in a sample of rock to help identify the rock type.

Igneous rock: The type of rock that forms when volcanic lava cools and hardens. Granite is one example.

Ion: An **atom** that has either lost or gained one or more **electrons**, which changes its **charge** from neutral to either positive or negative (respectively). In nature, crystals (like salt or quartz) are made of ions. While the term can refer to either positive or negative ions, it is often used to refer to positive ions, as in the case of **cosmic rays**, for example. **Electromagnetic radiation** that has enough **energy** to knock electrons free from atoms is called ionizing radiation because it creates ions by doing so.

This also makes it hazardous to biological tissue, since changing the charge on a **molecule** in the body will affect the chemical role it plays.

Isotope: **Atoms** of the same **element** can have different **masses** if they have different numbers of **neutrons** in their nucleus. This does not change the **charge** balance in the atom because neutrons are neutral, and it does not change the type of element because that depends only on the number of **protons**, which is not changing. Some isotopes are stable but others are **radioactive** and break down, emitting potentially dangerous radiation. By way of example, uranium has two primary isotopes, the more stable U^{238} isotope and the **radioactive** U^{235} isotope. Over 99% of uranium atoms have a mass of 238 atomic mass units; less than 1% have a mass of 235 amu. This is the reason uranium atoms must be separated in a centrifuge in order to collect enough U^{235} for use in a reactor or a bomb.

Kelvin (K): A unit of **temperature** when measuring on the absolute temperature scale, as opposed to the Celsius scale. Temperature is a measure of the average kinetic (movement) **energy** of the particles in a substance. A temperature of zero kelvin (0 K, which equals –273°C) is called Absolute Zero, and it represents a theoretical state in which all particle movement has stopped. A change of 1 K is the same temperature change as 1°C, but the two scales just measure from different starting points. In the Celsius scale, zero degrees (0°C) represents the freezing point of water, which is equal to +273 K.

Lichen: A mossy, plant-like organism that typically develops on rocks, trees, or other surfaces. It occurs when algae or bacteria live amongst different types of **fungi**, and it is usually one of the earliest type of organism to inhabit bare rock. Lichens begin the process of chemically eroding the rock because they absorbs nutrients from it. This activity also plays an important role in the process of soil development.

Light year (ly): The distance that light (**electromagnetic radiation**) travels in a year. Since the **speed of light** is 299,792,458 meters per second, which is about 671 million miles per hour, in one year light will travel a distance of 9.46 trillion kilometers, or 5.88 trillion miles. For reference, the Sun is 93 million miles from Earth, which would make it only 0.00001581 light years from Earth. The nearest star, **Proxima Centauri**, is 4.246 light years away, which is more than 250,000 times further from Earth than the Sun.

Magnetic permeability (μ_0): (*see* **spacetime**)

Magnetism: A force of attraction or repulsion resulting from the flow of electric current or the spin of a **charged** particle. According to both the **Williamson-van der Mark** and **Robinson models**, subatomic particles are comprised of a self-confined **photon** of the appropriate energy, a concentrated knots of **electromagnetic** radiation. In the toroidal, double-loop rotation of the **electron**, for example, **chirality**[23] is immediately a characteristic of the system, and this naturally divides 'spin reactions' (magnetism) into two complementary forms that we call north and south. They are simply the two relative chiral orientations of the rotating electromagnetic flow. In an electron, the (instantaneous) north magnetic pole lies along the axis running through the center of the torus, in the direction of the thumb in a left-handed chiral rotation. South lies in the opposite direction along the same axis. In an isolated electron, the magnetic field averages to zero (due to the electron's **spin**). The magnetic moment of the electron emerges in an external field, which breaks the internal symmetry of an isolated electron. This magnetic spin then extends its influence into the **spacetime** around it, distorting its **magnetic permeability**, which causes other magnetic fields to respond

[23] 'Spin handedness.'

when they encounter this distortion. The magnetic fields of other nearby electrons will therefore interact with this electron's field in such a way that north repels north but attracts south. This ultimately derives from the fact that **angular momenta** are either working together, lowering **energy** (attraction), or working against each other, increasing energy (repulsion). Unpaired electrons therefore have magnetic fields as a result of their spins and that of the photons that constitute them. When the unpaired electrons throughout a metal crystal align their magnetic spins, the crystal as a whole manifests a macro-magnetic field. One example of this is an iron ferromagnet. When electrons pair up, on the other hand, they superimpose in a way that finds them perfectly anti-parallel, and this cancels out their magnetic fields, significantly lowering their energy.[24] One example of this is the electron shell of a helium atom. This electron pair is no longer attracted towards other magnetic fields, but rather, repels them. This is called diamagnetism, and it happens in order to avoid disrupting and to maintain its perfect, low-energy, field-cancelling state.

<u>For the more technical and mathematically minded</u>: It is interesting to note that different forms of energy interact with spacetime in different ways.[25] The fact that magnetism is so closely related to spin is reflected in its mathematics. Whereas the underlying nature of the (3-component) electric field is that of the rate of change of space by time (dx/dt, dy/dt and dz/dt), the magnetic field is that of the rate of change of space by perpendicular space (dx/dy, dy/dz and dz/dx). Magnetic field is therefore a bi-vector quantity. A partial analogy is that of a spatial torsion or 'twist-bias,' though not a rotation since there is no time (t) component in these derivatives. While the

[24] John G. Williamson, Arnie Benn, Michael Mercury, "Quantum Spin Coherence In Four Derived 3-Spaces," *Quicycle* (2022) <u>https://quicycle.com/quicyclejournal/</u>

[25] *See* Williamson, Benn, Mercury (2022)

physical effect of an electric field on a charge is to accelerate it linearly, that of the magnetic field is to make it go round and round in circles. It is therefore no surprise that the combination of these — electromagnetic fields — usually spiral as they travel (when photons have circular polarization).

Magnetosphere: A region of magnetic fields that surrounds a star or a planet. It is believed to be generated by a magnetic dynamo action occurring within its core. A planet's magnetosphere deflects **charged** particles like **cosmic rays** around the planet, which serves to protect organisms living on its surface by reducing the amount of high **energy** particles and radiation they receive from space. It also helps preserve a planet's atmosphere because, without this magnetic shielding, the high energy particles and radiation can knock atmospheric molecules off into space. Over time, this can deplete the atmosphere entirely.

Mass: Radiant **energy** and matter are really two forms of the same **root-energy** 'stuff.' According to (the absolutely relativistic **sub-quantum mechanics** of) the **Williamson-van der Mark Model** and the **Robinson Model**, particles that have mass, such as **electrons**, are really **photons** of light that are traveling in a circle (or knot) rather than in a straight line. Such concentrated, self-sustaining photon resonance structures are the essence of matter. They confer mass on their particles by virtue of the way that rotating photons interact with the fabric of **spacetime** to generate **gravity**. The more matter is present, the greater the gravitational effect, and thus, the larger the mass.

Mass spectrometer: A device used to measure the **mass** and **charge**-to-mass ratio of **ions**. **Atoms** of the same **element** that have different masses are called **isotopes**. A mass spectrometer is able to measure the relative abundance of each isotope within an element. It is the way we know that over 99% of uranium atoms have a mass of 238 atomic mass units, and only less than 1% have a mass of 235 amu.

Molecule: A combination of two of more **atoms** bonded together. Simple examples include the hydrogen molecule (H_2), the oxygen molecule (O_2), and the water molecule (H_2O). More complex examples include protein and DNA molecules, which can contain thousands of atoms.

Mycotoxin: A toxic substance produced by a species of **fungi**. There are many different species of mushroom/fungi that produce mycotoxins that can be toxic to humans and animals, and some can even be lethal. Illness that is caused by exposure to a mycotoxin is called mycotoxicosis.

Neutron: The neutron is one of the three subatomic particles that make up **atoms**. The other two are the **proton** and the **electron**. Neutrons carry no **charge** and are found in the central nucleus of the atom along with the protons. Protons and neutrons each have more than 1800 times the **mass** of an electron. According to the standard model of physics, the neutron is believed to be a composite particle made up of three quarks — two 'down' quarks and one 'up' quark — that are held together by a binding **energy**. The quarks constitute about 1% of the neutron's mass-energy and the binding energy contributes the remaining 99%. According to the **Robinson Model**, like all subatomic particles, the neutron is made of a **photon** of light of the appropriate energy making two revolutions per wavelength. The primary difference is that a charged particle like the proton will be made of a circularly-polarized photon while a neutral particle like the neutron will be made of a plane-polarized photon. As a result of this plane-polarization, an isolated neutron is not stable and usually decays in less than 15 minutes, splitting into a proton, an electron, and emitting the additional energy in the form of an anti-**neutrino**. (This is the means by which the **angular**

momentum of all the particles involved in the transition is conserved.) When bound to a proton within a nucleus, however, a neutron is stable as a result of the resonance and field sharing between them. While in the case of the electron, the internal photon traces a toroidal path in (momentum) space as it completes its self-confined, double-loop rotation, in the case of the neutron, it is a little more complex. The neutron contains almost two thousand times more mass-energy than the electron, and its rotating photon resonance therefore contains higher energy **harmonics** — 1/3rd, 1/9th, and 1/27th harmonics. Since quarks have never been isolated and seem to occur only in their resonant groupings of three, the photon harmonics of the Robinson Model may provide insight into why quarks do not occur except as part of such a stable resonance. In atoms, neutrons are important because they separate the positive protons, whose like charges repel, from one another. Neutrons are therefore necessary in any nucleus containing more than 1 proton. More significantly, they also *bind* the protons together *electrostatically* since, according to the Robinson Model of Nuclear Binding, the exterior 1/27th photon resonance of the neutron is negative, and binds to the positive exterior resonance of the proton through an overlapping 'division-by-zero' attraction.[26] As a result of being made of a rotating photon, a neutron has a **quantum spin** of S=½. The mass of the neutron (939.6 MeV) is very similar to (though slightly larger than) the combined masses of the proton (938.3 MeV) and electron (0.511 MeV). The difference in their masses represents the difference in energy between the neutron state and the electro-proton state that is the hydrogen atom. The neutron's lack of charge arises from the fact that the orientation of its internal plane-polarized photon's electric field, as it makes its double loop rotation, is such that the positive

[26] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 5.
See also www.Quicycle.com

and negative fields alternate pointing outwards. While each resonant element within the neutron's structure has charge, the overall result is a net neutral charge for the particle.

Neutrino: The neutrino is the smallest stable subatomic particle. It has no **charge**, no **magnetic** moment, a **spin** of S=½, and an exceedingly small rest **mass**-energy of the order of 10^{-4} eV. That **energy** corresponds to the peak energy of the cosmic microwave background radiation **temperature** of ~2.7°K. Cosmological neutrinos constitute by far the most common component of the universe with a density of about 10^{12} neutrinos per cubic meter.[27] Like the **electron**, it is comprised of a single **photon** of the appropriate energy making two revolutions per wavelength. Neutrinos can travel at very high speeds approaching the speed of light. While they do not easily interact with matter, neutrinos can be either captured or released during the process of one subatomic particle morphing into another. When a **neutron** decays into a **proton** and an electron, for example, an anti-neutrino is also produced as a by-product of the reaction, and it will have a spin opposite to that of the electron (see **nuclear reaction**). This is the means by which the **angular momentum** (spin) of all the particles involved in the transition is conserved. In addition, the universe is literally completely filled with neutrinos. Like electrons, neutrinos are not point particles. They are rotating photon loops, just like all other particles, and they have size. There are over a million cosmic neutrinos in every cubic millimeter of space, and each one has a radius of about 2 millimeters. That provides a continuous effect through all of space, a 'substrate' with the same quantum *spin* as the electron, through which all photons must travel. According to the **Robinson Model**, this increases the viscosity of **spacetime** for the photons traversing it, which causes a slight loss of energy, which results in the **redshift** of cosmic photons.

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[27] *See* Robinson, *ibid.*, chapters 3 & 11.

Newton's third law: For every action there is an equal and opposite reaction. This means that if two people are floating beside each other in zero **gravity** and one acts by pushing the other to the left, the one who did the pushing will react by recoiling to the right. Another example includes the physics of a rocket booster. When exploding gas is allowed to escape in only one direction, backwards, then the closed side of the rocket engine that is resisting it will be pushed in the opposite direction, forwards, and with equivalent force.

Nuclear reaction: A reaction in which the nucleus of an **atom** undergoes a change. These changes can include: two atomic nuclei fusing to form one new larger one, as in the case of nuclear fusion; one nucleus splitting to yield two new smaller nuclei, as in the case of nuclear fission; a **proton** or **neutron** morphing or 'transmuting' into the other, which involves either the absorption or emission of radiation, matter, or **antimatter** particles. One example of a nuclear reaction would be when a neutron (n^0) decays into a proton (p^+), an **electron** (e^-), and an (anti-electron) **neutrino** ($\bar{\nu}_e$), or the reverse: $n^0 \rightleftarrows p^+ + e^- + \bar{\nu}_e$.

Nucleotide: (*see* **DNA**)

Orbit: A state of continuous free-fall where one object, a satellite, is revolving around a much more massive object such as a planet. The satellite is attracted to the planet by gravity, while its velocity wants to send it flying off into space. When these two forces are exactly equal, the satellite remains the same distance from the object and an orbit has been achieved. Satellites can orbit at various speeds and altitudes. The speeds are fixed by the **mass** of the planet and the altitude of the orbit.

Paleozoic era: A geological era on Earth from about 539 million years ago to about 252 million years ago. It is subdivided into six geological **time** periods, the **Cambrian**, Ordovician, **Silurian**, Devonian, Carboniferous, and **Permian** periods.

Parsec: A distance of about 3.26 **light years**. **Proxima Centauri** is 1.3 parsecs from Earth. (A parsec is *not* a length of **time**, and if Han Solo had in fact done the infamous Kessel Run in his speedy Millennium Falcon, he would have known that.)

Pathogen: An organism that causes disease or illness. These include bacteria, viruses, **fungi**, and various other kinds of micro-organisms.

Permian Period: A geological period on Earth from about 299 million years ago to about 252 million years ago. It constitutes the last period of the **Paleozoic** era, and is characterized by the diversification of, amongst other things, insects and reptiles.

Photon: A **quantum** (or 'packet' or 'bullet') of light **energy**. **Electromagnetic radiation** travels in discrete packets called photons. It does not travel in a continuous stream, as we might imagine when we look at a beam of light or a laser. There are so many photons being released so rapidly by a light source that it only gives the impression of being a continuous beam. Photons travel in a straight line in the case of light radiation, or in a self-confined double-loop torus-shaped rotating 'knot' in the case of the subatomic particles[28] (see **proton**, **neutron**, **electron** & **neutrino**). In either case, the photon itself can either be plane-polarized or circularly-polarized around its axis of travel.

Photosynthesis: The process by which a plant cell captures sunlight and uses that energy to convert carbon dioxide (CO_2) from the air and water (H_2O) into sugar ($C_6H_{12}O_6$) molecules that it can then use as food/fuel. This is the point at which sunlight is

[28] According to the **rotating photon model** of matter proposed in the **Williamson-van der Mark** and **Robinson Models**.

captured and made available, as food energy, for living organisms. Since animals do not have photosynthetic skin, they must rely upon eating plants in order to mine that food energy for their own bodies — energy that came directly from the Sun. Animals have no choice but to get this energy either by eating plants, or by eating other animals who got it by eating plants. In plant cells, photosynthesis takes place in small green organelles called chloroplasts. The type of chemical **molecules** that facilitate the actual photosynthetic capture of energy are called chlorophylls. Different chlorophyll molecules can absorb light radiation at different **wavelengths**, and as a result, we find different chlorophyll molecules in surface plants, for example, than we do in plants that live at depths in the ocean where only the longer wavelengths of sunlight tend to penetrate.

Plasma: A state of matter where **electrons** have become separated from **atoms**, resulting in the presence of negatively **charged** electrons and positively charged atomic **ions**. It often involves high **temperature** environments since these have enough **energy** to ionize (eject) electrons from atoms. Plasmas are characterized by current flow since they contain movable charges that will seek charge equilibrium. Most of the matter in the universe is in the form of plasma. The **solar wind** and lightning are examples of a plasmas.

Port side: The left side of a boat or aircraft when facing forward. Centuries ago, before the use of a rudder, ships were steered from the rear with a steering oar located on the right side of the ship. In order to avoid it, when entering a port, the ship would tie up at a dock on its left side. The port side had previously been called the larboard side, meaning the side where the loading was done, but it was later changed due to its similarity to **starboard**.

Positron: A positively **charged** subatomic particle, identical to the **electron**, except that it has the opposite charge. It is the electron's 'anti-particle,' and this illustrates the concept of **antimatter**. It is 'anti' in the sense of its charge being opposite. According to the **Williamson-van der Mark model**, like the electron, it is made of a single **photon** of light making two revolutions per wavelength, though its rotating photon has opposite **chirality**. A positron is thus a self-confined knot of concentrated light **energy** traveling around itself at the **speed of light**, and it therefore has a toroidal (donut-shaped) substructure in (momentum) space. As a result of the geometry of this double-loop torus, the photon's positive electric field is pointing outwards at all times, which is what gives the positron its positive charge. When an electron and a positron meet, they unlock each other's photons' **angular momenta**, converting their rotating photons to linear photons in an explosion of pure energy called a matter-**antimatter** annihilation[29]. A positron has a right-handed spin of S=½, a charge of $C=+1.6\times10^{-19}$ Coulombs, and a **mass**-energy content of 511 keV.

Pressure (of a gas): This is the force exerted by all of the collisions of the individual particles in a gas as they strike a surface randomly. The more particles are present in a given volume, the higher the pressure because there will be more collisions against its surface, expressing itself as a larger overall force against that surface. The higher the **temperature** in a given volume, the higher the pressure because gas particles move faster at higher temperatures (*see* **energy**), and they will therefore be colliding against its surface with more force.

Protein: A very long **molecule**, a polymer made up of many individual building-block molecules called amino acids that are assembled into a long chain. Proteins are a key component of and a nutrient for many living organisms. They are made inside cells by small structures called ribosomes. In order to make a

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[29] See the image in the 'NOTE' at the beginning of the book, which presents this concept according to the **rotating photon model** of matter.

protein, a section of the **DNA** molecule is replicated, making an **RNA** molecule that is used as a template. Amino acids are then assembled in the correct order according to the (nucleotide) code in that (RNA) template, and this results in a protein chain being assembled according to the instructions in the DNA code. While the DNA helix is assembled out of only 4 different nucleotides — A, T, G, or C — there are 21 different amino acids in nature that are used to assemble our proteins, and this means that proteins can come in an almost endless variety. The amino acids in the protein chain can also interact with one another, which bends the protein molecules into all manner of unique shapes that have very important biological implications.

Proton: The proton is one of the three subatomic particles that make up **atoms**. The other two are the **neutron** and the **electron**. Protons are stable, carry a positive **charge**, and are found in the central nucleus of the atom along with the neutrons. The electrons surround the nucleus in a cloud of negative charge density. Protons and neutrons each have more than 1800 times the **mass** of an electron. According to the standard model of physics, the proton is believed to be a composite particle made up of three quarks — two 'up' quarks and one 'down' quark — that are held together by a binding **energy**. The quarks constitute about 1% of the proton's mass-energy and the binding energy contributes the remaining 99%. According to the Robinson Model[30], like all subatomic particles, the proton is made of a **photon** of light of the appropriate energy making two revolutions per wavelength. While in the case of the electron, the internal photon traces a toroidal path in (momentum) space as it completes its self-confined, double-loop rotation, in the case of the proton, it is a

[30] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 5.
See also www.Quicycle.com

little more complex. The proton contains about 1836 times more mass-energy than the electron, and its rotating photon resonance therefore contains higher energy **harmonics** — one-third and one-ninth harmonics. Since quarks have never been isolated and seem to occur only in their resonant groupings of three, the photon harmonics of the Robinson Model may provide insight into why quarks do not occur except as part of such a stable resonance. Protons are important because atoms of a given **element** are identified according to their number of protons. This is called the atomic number, and the periodic table of the elements is laid out in order of atomic number. The first element on the periodic table, hydrogen, has 1 proton. The second element, helium, has 2 protons, and so on. It is also the presence of the protons in the central nucleus that attracts electrons to neutralize their charge, and thereby, complete the neutral atom. Neutrons are attracted into the mix in order to both separate the protons from one another (since their like positive charges repel one another) and also to bind the protons together (since, according to the Robinson Model of Nuclear Binding, the exterior resonance of the neutron is negative). As a result of being made of a rotating photon, a proton has a **quantum spin** of S=½. It has a mass-energy content of 938.3 MeV and carries a charge of $+1.6\times10^{-19}$ Coulombs. Its charge arises from the fact that the orientation of its internal circularly-polarized photon's electric field, as it makes its double loop rotation, is such that the positive field is outwardly directed for the majority of its harmonic oscillations, and in particular, the outermost one. This results in a net positive charge for the particle.

Proxima Centauri: The nearest star to our solar system, at a distance of 4.2465 **light years**. It is a part of a three-star system called **Alpha Centauri**.

Psilocybin: A naturally-occurring psychedelic/hallucinogenic compound found in many species of **fungi**.

Quantum: 'Quantum' means 'countable.' It means that something happens in integer units. It implies that changes must occur in discrete steps rather than a smooth, continuous gradient. These 'quantum leaps' of change mean that the process or system is quantized. Stairs and piano keyboards are examples of things that are quantized. Ramps and violins are not. The fundamental reason for quantization is that waves **resonate** in multiples of their wavelengths, rather than at arbitrary points in between. Subatomic particles are made of photons that make double-loop rotations. They are only stable if their rotations are in multiples of double-loops. A "quantum" of light is called a **photon**, and it is the amount of **electromagnetic energy** that is emitted, transmitted, or absorbed in a quantum inter-action. A photon can even have a very high energy, which means that each packet of energy at that wavelength carries a large amount of energy. An example is the gamma ray. **Electron** clouds in **atoms** can also only manifest certain discrete electron states. This is because each electron is an identical unit, and because their interactions result in discrete, resonant, stationary wave states. Electron clouds transition between adjacent energy states by emitting or absorbing whole photons (or electrons) — one quantum at a time.

Quantum gravity: (*see* **Gravity**)

Quantum mechanics: The science that describes light, subatomic particles, and their **quantum** interactions. It is based upon the idea that all interactions are quantized. Particles and **energy** states can be described by equations called wave-functions, since they *are* resonant wave states made up of **photons**.

Quantum spin: (*see* **spin**)

Radiation: This usually refers to **electromagnetic radiation**, but the term is sometimes applied to (a flow of) particles, for example **radioactive** beta emissions, in which case the radiation involves electrons, or **cosmic rays**, in which case the radiation involves positive **ions**.

Radioactivity: In the nucleus of an **atom**, **protons**, which carry a positive **charge**, will repel each other unless they are held together by bonding (electrostatically[31]) to **neutrons** (whose outer regions carry negative charge). The balance between protons and neutrons in the nucleus is therefore very important. If a nucleus has either too many or too few neutrons, it lacks stability, and it may therefore begin ejecting or transmuting some of its subatomic particles in order to reach a stable configuration. This is called radioactivity, and it involves the ejection (or sometimes the absorption) of one or more subatomic particles (or antiparticles) or a **photon** of **electromagnetic radiation**, or both, from the nucleus. Alpha radiation occurs when two protons and two neutrons are ejected in a cluster with a 2+ charge called an alpha particle (which is identical to the nucleus of a helium atom). Beta radiation occurs when a neutron in the nucleus morphs into a proton by ejecting an **electron** and a **neutrino** (see **nuclear reaction**). A radioactive decay therefore often results in the atom turning into a different **element**. In the case of gamma radiation, only a (gamma ray) photon will be emitted, and the type of element will not be changed. Almost all of the radioactive atoms on the periodic table are those with high atomic numbers and large nuclei.

Red dwarf star: The smallest and coolest star type in the 'main sequence' classification of stars. It is thought to be one of the most common types of star in our Milky Way **galaxy**, even though they are too dim to be seen with the naked eye.

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[31] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 5.
See also www.Quicycle.com

Proxima Centauri is a red dwarf star, as are nine of the next eleven nearest stars to our solar system.

Redshift (*z*): This refers to the stretching of the **wavelength** of light radiation. It can be a perceived stretching, like the **Doppler effect,** or an actual physical effect when a **photon** interacts with **mass** and **gravity,** or when traversing the 'viscosity' of space. The Doppler effect redshift occurs when a light[32] source is getting further away, either because we are moving away from it or it is moving away from us. This gives us the impression that its wavelength is getting longer and its **frequency** lower. The longer wavelengths of visible light lie towards the red end of the rainbow spectrum, which means redshifted light literally gets redder, and hence the name. Redshift can also result from a **photon** propagating directly away from a gravitational field.[33] Photons have inertial mass, and they are therefore affected by gravity. Such interactions will reduce their **energy**. A reduction in photon energy means a reduction in its frequency, and since the **speed of light** is constant, this results in an increase in its wavelength. According to the **Robinson Model**, when photons travel vast distances through space, they also lose momentum energy very gradually as a result of the viscosity of the space through which they are traveling. This is caused by the ubiquitous presence of about 10^{13} cosmic **neutrinos** per cubic meter of space.[34] These provide a continuous 'substrate' or matrix of rotating photon field distortions (i.e. electromagnetic

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[32] In the case of sound waves, the **Doppler effect** causes a sound source that is approaching to have its pitch raised, and one moving away to have its pitch lowered, as we experience when an ambulance siren passes by.

[33] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 8-9.

[34] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 11.

waves) to every point in space, through which every photon must propagate.

Relativity: According to Albert Einstein's Special Theory of Relativity, published in 1905, the **speed of light** is always constant for every observer, no matter their environment or how fast they are traveling relative to the light. The consequence of this is that other perceptions become distorted in order to maintain this absolute. One example is that **time** flows at a different 'pace' for observers who are traveling at very different speeds, especially when one or both of these speeds are a significant percentage of the speed of light (*see* **Time dilation**). That is why high-speed cosmic travelers over large distances will always return home to find they have aged less than those they left behind. Calculating these differences is called a relativistic correction. The closer one travels to the speed of light, the more exponentially one's perception of time will differ to those who remain 'stationary' on a planet. Since particles are made of rotating **photons** of light **energy**, these relativistic corrections automatically apply to all matter particles — their 'internal clock,' length, and **mass**.

Resonance: (*see* **Harmonic resonance**)

Robinson Model of Nuclear Binding: (*see* **Neutron**)

Robinson Model of Quantum Gravity: (*see* **Gravity**)

Root-energy: In the theory of **sub-quantum mechanics**, root-energy refers to quantities that need to be 'squared' in order to represent an **energy**.[35] These include the electric field and the quantum mechanical wave function, **ψ**.[36]

Rotating Photon Model: The rotating **photon** model of matter describes the origin of and physical reasons for properties such as the special **relativity** corrections, why ***E=mc²***, the de Broglie wavelength, **chirality**, parity, the distribution of **charge** and **magnetic** field, and more.[37] This model proposes that each subatomic particle is comprised of a photon of the appropriate **energy** completing two revolutions around its toroidal double-loop rotation path for every one **wavelength**. This is also the source of a particle's half-integral **spin** (½*ħ*). This model is proposed by John G. Williamson and Martin B. van der Mark, as well as by Vivian N.E. Robinson. (*See* **Sub-Quantum Mechanics** *and* **Electron**.)

RNA: When a strand of **DNA** code is copied for the purpose of making a **protein**, only one strand of the DNA's double helix is copied. The resulting copy is a single molecular strand of nucleic acid called RNA, which stands for *ribonucleic acid*. Like DNA, an RNA strand is a polymer that involves four different nucleotides, except that the thymine (T) nucleotide (found in DNA) is replaced by a uracil (U) nucleotide. RNA therefore contains the letters AUGC (rather than ATGC). It is this RNA **molecule** that attaches to the ribosomes inside of cells. It is then read, like a template, in order to assemble the right amino acids in the right order to make the desired protein molecule.

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[35] *See* Williamson, Benn, Mercury (2022), (*see* **Magnetism** *above*).

[36] In **quantum mechanics**, energy density is proportional to $\psi^\dagger\psi$.

[37] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 2-3.

Sedimentary rock: A type of rock formed when silt or sediment becomes deposited in layers at the bottom of a body of water, and then these layers become hardened and compacted over geological timescales due to the heat and pressure associated with tectonic activity. Sedimentary rock therefore has a characteristically layered appearance.

Silurian Period: A geological period on Earth from about 444 million years ago to about 416 million years ago. It falls into the early **Paleozoic** era, and is characterized by mosses and vascular plants, the expansion of **fungi**, and the appearance of terrestrial arthropods.

Solar system: A central star surrounded by **orbiting** planets, asteroids, comets, and other debris. In our solar system, the Sun is that central star. There are many other star systems in which orbiting planets, **exoplanets**, have been identified.

Solar wind: The flow of high-**energy** particles and radiation given off by a star, such as our Sun. This material is hot, travels fast, and can be hazardous to organisms and equipment in space. Solar wind particles also exert pressure, and as such, the use of solar sails has been proposed in order to propel spacecraft.

Spacetime: The fabric of space and **time**, whatever it actually is, has two basic properties that we consider: its electrical permittivity (ε_0) and its magnetic permeability (μ_0). The former describes the extent to which spacetime can hold (or allow the passage of) electric fields, and the latter, the same for magnetic fields. These properties are intimately related to the **speed of light** *(c)* because light is **electromagnetic** and interacts with space electrically and magnetically. **Photons** of light can only travel *because* they interact electrically and magnetically with spacetime. The three properties are related by the equation $\varepsilon_0\mu_0=1/c^2$. The term spacetime also relates to the fact that space and time are part of the same 'stuff' — inseparable — something that may seem unintuitive since we tend to think of them as separate. Spacetime is also distorted by the presence of **mass**, which gives rise to **gravity**. **Relativity** describes how aspects of space and time appear to become distorted under certain conditions so that the speed of light should appear constant to every observer in every reference frame.

For the more technical and mathematically minded: It is interesting to note that different forms of **energy** interact with spacetime in different ways[38]. The three variables of space are *x*, *y*, *z*, and the one variable of time is *t*. Spacetime is therefore 4-dimensional: *x*, *y*, *z*, *t* (and their inverses). The underlying nature of electric field is that it is a (3-component) flow, a rate of change of space by time (*dx/dt*, *dy/dt* and *dz/dt*), like velocity. The underlying nature of the (three component) magnetic field is that it is a twist, a rate of change of space by perpendicular space (*dx/dy*, *dy/dz* and *dz/dx*). No *t*. It makes things go round in a circle. **Angular momentum** (**spin**) is the rate of change of momentum with respect to perpendicular space, taking the form of *d/dx*(*dy/dt*).

Spectroscope: A device for measuring and analyzing light. It is a very important tool for identifying chemical **elements** and **molecules**, and is consequently of great use not only in chemistry and physics, but also in astronomy. Specific **atoms** and molecules interact with light **energy** in very specific ways — at very precise energies — and therefore at characteristic **frequencies**. The light that is absorbed or emitted by a substance or by an astronomical body can therefore provide us with much detailed information about its chemical makeup and properties.

[38] *See* Williamson, Benn, Mercury (2022)

Speed of light (*c*): Light (**electromagnetic radiation**) travels at a fixed and finite speed of 299,792,458 meters per second, which is about 671 million miles per hour. According to Einstein's Special Theory of Relativity, the speed of light appears constant to every observer everywhere, no matter where they are or how fast they are traveling. The speed of light is defined according to how fast it can travel through **spacetime** (*see above*). It is therefore defined in relation to the properties of spacetime, according to the equation $c^2=1/\varepsilon_0\mu_0$.

Spin (S): According to both the **Williamson-van der Mark** and **Robinson models**, many subatomic particles have spin because they are made of a self-confined **photon** of light traveling in a circle, a double-loop rotation, at the **speed of light** (*see* **electron**). This is **angular momentum** at the **quantum** level. In the case of a **charged** particle, such as the electron, the (circularly polarized) photon of light making up the particle also has an intrinsic angular momentum because its fields spiral around its axis as it travels. According to the Williamson-van der Mark model[39], electrons may also contain a third level of angular momentum, since the photon's intrinsic spin should cause the ring-shaped structure to tumble in order to conserve angular momentum (depending on the presence of an external magnetic field). According to the Robinson model[40], only charged particles contain intrinsic photon spin because they are made of circularly-polarized photons. Neutral particles are made of plane-polarized photons, and their angular momentum therefore arises entirely from their photon's double-loop rotation.

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[39] *See* Williamson (2019).

[40] *See* Robinson, *How to Build a Universe: Beyond the standard models* (2021), chapter 3.

Star flare (or solar flare): It occurs when the light and radiation emitted by a star experience a sudden increase in intensity. They are believed to be caused by the release of **energy** resulting from a process known as **magnetic** reconnection.

Starboard side: The right side of a boat or aircraft when facing forward. It derives from the old English term for "steering side." Centuries ago, before the use of a rudder, ships were steered from the rear with a steering oar. It was located on the right side of the ship since most people would use their right hand to do the steering while facing forward.

Sub-quantum mechanics: An absolutely relativistic **quantum mechanics** that does not begin with the particle as an axiom, but investigates the **rotating photon** substructure that gives rise to its properties. It is built upon the theory of absolute relativity forwarded by John G. Williamson[41] and Martin B. van der Mark, and is encapsulated by the Williamson equation[42] $\mathscr{D}_\mu \mathbf{\Xi}_\mathscr{G} = 0$, where $\mathscr{D}_\mu$ is a Dirac-Clifford four-vector derivative, and $\mathbf{\Xi}_\mathscr{G}$ is the **root-energy** in sixteen **spacetime** forms including a Lorentz-invariant scalar 'point' **mass**-energy.

Supernova: The extremely bright explosion of an old star. It sends large amounts of light, high **energy radiation**, and **cosmic rays** out into the universe. It is believed to have several possible causes, the primary two being the gravitational collapse (implosion) of the core of a massive star that is exhausting its hydrogen (fusion fuel), or a white dwarf star in which fusion is re-ignited. During a supernova, many lighter atomic **elements**

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[41] *See* Williamson (2019); *See also* Martin B. van der Mark, John G. Williamson, "Relativistic Inversion, Invariance and Inter-Action," *Symmetry* 2021, 13, 1117. https://doi.org/10.3390/sym13071117

[42] Pronounced "D-mu ksi-G equals zero."

become fused into large ones, and this is the process by which the elements of the periodic table are believed to be formed.

Temperature: A measure of the average kinetic (movement) **energy** of the particles in a substance. The higher the temperature, the faster the **atoms** or **molecules** move or vibrate. Absolute Zero, a temperature of zero **kelvin** (0K or –273°C), represents a theoretical state in which all particle movement has stopped. Water freezes at +273K (or 0°C), and boils at 373K (100°C). The Sun's surface temperature is just under 5,800K, but its corona has a temperature exceeding a million degrees.

Time (*t*): A quantity measured in terms of the regular vibrations or oscillations — the **frequency** — of a **harmonic** system. Typical examples include using a complete revolution of the Earth around the Sun to designate a year, a complete rotation of the Earth on its axis to designate a day, or the vibrations of a cesium **atom** in an atomic clock to designate a second. The reason that time is measured in seconds (*sec*) is because frequency is measured in "per second"s (1/*sec*), and an event's duration is the inverse of how frequently it occurs. Time is also not a separate 'thing,' but is intimately interconnected with the concept of space (*see* **spacetime**). Since all **radiation** and matter in the universe are made of **photons**, and since all photons are **energy** waves of a specific frequency traveling at the **speed of light**, **Relativity** will affect our perception of frequency, and therefore our perception of the flow of time.

Time dilation: When an observer is moving at relativistic speed, meaning a speed that is some meaningful percentage of the **speed of light**, they will perceive the passage of **time** differently than people who are not traveling with them. The equation that shows how much time passes for one (*t*), relative to the other (t_0), uses the speed of light (*c*) compared to the observer's traveling speed (*v*) in the equation $t = t_0 \div \sqrt{(1-v^2/c^2)}$.

Example: How much time will you experience if you are traveling from Earth to **Proxima Centauri**, a distance of 4.2465 **light years**, at a speed (*v*) of 99.88% the speed of light? While those remaining on Earth will observe the journey to take 4.2465/0.9988 = 4.2516 years, the high-speed traveller will have their experience of time dilated, and they will observe their journey taking: $4.2516=t_0\div\sqrt{(1-0.9988^2)}$, so $t_0=0.208$ years or 76 days or 2.5 months.

Titan: The largest moon of Saturn, and the second largest moon in the solar system after **Ganymede**. It is the only solar system moon known to have a dense **atmosphere**, which is made up of mostly nitrogen (N_2) along with various hydrocarbons.

Wavelength: The distance from the beginning of one wave to the beginning of the next — the length of one complete cycle of a wave. With **electromagnetic** (light) waves, when wavelength (λ) increases, **frequency** *(ν)* decreases, and vice versa. This is because the **speed of light** *(c)* is constant, and the three are related by the equation $c=\lambda\nu$.

Williamson-van der Mark Model: The **rotating photon** model of the **electron**[43], proposed by John G. Williamson[44] (*CERN/Glasgow University*) and Martin B. van der Mark[45] (*Philips*). It features an absolutely relativistic **sub-quantum mechanics** reflected in the Williamson equation[46] $\mathscr{D}_\mu\Xi_\mathscr{G} = 0$, where $\mathscr{D}_\mu$ is a Dirac-Clifford four-vector derivative, and $\Xi_\mathscr{G}$ is the **root-**

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[43] *See* Williamson, van der Mark (1997); Williamson (2019); van der Mark (2019) cited above (see **electron**).

[44] https://scholar.google.com/citations?hl=en&user=z2tP0y4AAAAJ

[45] https://scholar.google.com/citations?hl=en&user=0jByzgoAAAAJ

[46] Pronounced "D-mu ksi-G equals zero."

energy in sixteen **spacetime** forms including a Lorentz-invariant scalar 'point' **mass**-energy.

Zero-G: A state in which no **gravity** is felt by a body, when all external forces acting on it are in balance. This can occur when the body is stationary or moving at a constant velocity. (Gravitation is an accelerating force, but there is no acceleration when a body is moving at a constant velocity.) As a result, when all external forces acting on a body are in balance, it experiences weightlessness because it is not being pulled preferentially in any direction, relative to its immediate environment. It is therefore as if there is no force of gravity acting on the body. Weightlessness is experienced, for example, (a) when one is traveling at a constant velocity in space, though nowhere near any large masses, or (b) when one is in a state of free fall or orbit around a planet — when outward (tangential) velocity exactly balances inward gravitational attraction, or (c) when one is in the belly of a movie industry airplane that is in a parabolic dive designed to simulate zero-G for a movie shoot.[47] If a weightless floating object is bumped or pushed, this new imbalance of forces will cause it to move, and keep moving until some other force or object causes it to stop or move differently. (*See also* **Newton's third law** *above*.)

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[47] Ron Howard used this technique to film several scenes in the movie "Apollo 13."