

COSMIC CONNECTIONS

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I AM A PROFESSED FRANCISCAN,¹ largely because my spirit resonates with Francis' joyful recognition of the universe being the Cosmic Christ. His praises of 'Brother Sun' and 'Sister Moon'² point us towards the stars and help us to see God's love everywhere. As a scientist³ I am drawn to Francis' insights into cosmology and his preaching on mankind's stewardship of Nature. In 2007 I visited Francis' Sanctuary outside Assisi and was astonished to see a tableau of bronze figures portraying Francis teaching his companions a stargazing technique to find the North Star. This would aid them in their itinerant ministry and to set up an east-facing altar. Reflecting on this unexpected image of 'Francis the Stargazer', I wondered whether the scientific forces holding our material cosmos together might have spiritual counterparts in various types of love, particularly as described by C. S. Lewis.⁴ I now believe that they do.

The Four Forces of the universe are, in order of increasing strength: the Gravitational Force, the Weak Force, the Electromagnetic Force and the Strong Force. The Four Loves, described by Lewis, are: Charity, Affection, Friendship and Eros. A parallel may be drawn between these two sets of four things to suggest that the four loves are the spiritual equivalents of the physical laws of attraction. Let us first examine the physical laws of attraction, starting with the weakest.

Gravity

Everyone is aware of the force of gravity because it keeps our feet on the ground. Without it the earth would have lost its atmosphere long ago and the moon would no longer orbit the earth, or the earth orbit

¹ I was professed a Tertiary of the (Anglican) Society of Saint Francis, at Oxford, in February 2006.

² 'Canticle of the Sun', see Lord Longford, *Francis of Assisi: A Life for All Seasons* (London: Weidenfeld and Nicholson, 1978), 75–76.

³ Employed at the Atomic Energy Research Establishment, Harwell, Oxfordshire.

⁴ See C. S. Lewis, *The Four Loves* (New York: Harcourt Brace, 1960).

the sun. If gravity were to cease then life on earth would end. The force of gravity is pervasive, persistent and responsible for holding the planets, moons and sun together in our solar system. And gravity holds the solar system in place inside our galaxy. Sir Isaac Newton was the last of the great philosopher-scientists, and the first 'new scientist' to examine gravity and establish its law. The story is told of how Newton fell asleep under an apple tree and was woken up by a falling apple, causing him to wonder, 'Why does the apple fall *downwards* and not fly upwards?'

The apple, initially fastened to the tree, becomes detached and starts to move away from the branch. It accelerates from rest to whatever speed is attained by the time it hits the ground. Newton knew, because he had performed measurements on moving objects in his laboratory, that the apple must have experienced an external force in order to accelerate in this way. What was the force causing the apple's motion? It did not matter how high up the tree the apple started off: it would always fall to the ground. So the force acting on the apple would have to be acting upwards, at least to the height where the apple was.

Newton then had a flash of inspiration: if the force of gravity reaches to the top of the highest apple tree, growing on the top of the highest mountain, then might gravity's effects reach beyond the atmosphere all the way to the moon? If so, the orbit of the moon about the earth would be a consequence of the gravitational force acting on it. This force would be responsible for holding the planets in their courses around the sun.⁵ Newton established that the strength of gravitational force depends upon the mass of the object. The earth has a much larger mass than an apple and is capable of generating a much greater gravitational force, so the earth wins the contest as to which way the apple will move—downwards.

Newton concluded that all matter had this intrinsic property called 'gravitational force', resulting in an attraction between any two bodies. He worked out the law of gravity, showing that its strength was proportional to the mass of the one body multiplied by the mass of the other body divided by the distance between them squared. All matter, even a single atomic particle, is attracted to all other matter in the universe according to this physical law.

⁵ Newton published his ideas on celestial mechanics in *Philosophiae Naturalis Principia Mathematica* in 1687.

Newton's Law of Gravitation

If the two masses **M1** and **M2** are separated by a distance **D** then the Gravitational Force between them is **G** x **M1** x **M2** divided by **D²** where **G** is the universal Gravitational Constant.

The value of 'G' is extremely small, and consequently the force of gravity between two small objects is tiny. Although gravitation is weak and we cannot sense its presence, we can sense its effects and it holds us to the ground simply because the earth is so massive compared to our own mass. The effects of gravity between planets, moons and star-sized objects are very powerful. It is an all-pervading force affecting every part of the universe. Gravity can bend space-time⁶ yet it remains the weakest of the Four Fundamental Forces.

Electromagnetism

Electromagnetism describes the relationship between electricity and magnetism. An electric current passing along a copper wire generates a magnetic field going round the wire. If we then wrap the wire around a iron bar, the bar becomes magnetic. When the electric current is turned off the bar's magnetism disappears. Iron, nickel and cobalt can easily be magnetised in this way and are important in the application of electromagnetism to useful devices such as electric motors and dynamos.

Michael Faraday⁷ constructed the first ever electric motor and its converse—the dynamo. Today we use electromagnetism to generate electricity, store data in our computers, make pictures on a television screen and carry out medical diagnostics. Faraday demonstrated that electric currents generate magnetism and can cause mechanical movements: in an electric motor the magnetic field causes the motor spindle to rotate. In the average home we may find well over two dozen electric motors keeping our lives ticking over!

Electromagnetism is a more powerful force than gravity but, like gravity, its effects weaken rapidly with distance. It is the force that

⁶ 'Space-time' was used by Einstein in his Special Relativity Theory in 1906. The term, meaning three dimensions plus time, had already appeared in the fiction of Edgar Allan Poe and Jules Verne.

⁷ Michael Faraday (1791–1865) was an outstanding scientific experimentalist and Fellow of the Royal Society.

holds atoms and molecules together and is responsible for the forms taken by matter in the world.

The Strong Nuclear Force

This is the strongest of the four fundamental forces, and is responsible for holding an atom's nucleus together. The nucleus consists of a number of protons⁸ and neutrons. Neutrons have no charge, but the presence of positively charged protons means that the nucleus is continuously trying to fly apart because each proton repels all the others. What prevents the nucleus from exploding is that its protons are held together by the Strong Force.

A similar situation exists inside the protons themselves, which consist of three quarks.⁹ Scientists describe quarks as being the basic building blocks of atomic particles. Every proton and neutron is formed by a group of three different quarks and they are held together by special sticky particles known as gluons. It all sounds very weird, yet subatomic matter would not exist without the presence of the Strong Force binding quarks together.

Quarks, gluons, protons and neutrons consist of different vibrations of electromagnetic energy and are quite invisible to us. Yet because the Strong Force holds them in their correct places these vibrations appear to us as solid. Not surprisingly the Strong Force is very strong; being around six thousand trillion, trillion, trillion times more powerful than gravity, but it acts over a very short range, limited to the tiny volume occupied by the particle that it is holding together.

The Weak Nuclear Force

The Weak Nuclear Force is one millionth the strength of the Strong Force and it also exists inside atomic matter. In fact it is such a short-range force that it operates across a space of 0.1 per cent of the diameter of a proton! Its effective range is a thousand times smaller than the Strong Force, yet it is vital to the fusion process that causes

⁸ The lightest atom, hydrogen, contains a single proton but the heaviest element, uranium, contains 92 protons.

⁹ The existence of quarks was proposed by the physicists Murray Gell-Mann and George Zweig in 1964 and, although yet unobserved, they are thought to be subatomic particles possessing fractional electric charges. They were named after a passage in James Joyce's *Finnegans Wake*.

the sun to burn. It is also essential in radioactive decay, enabling one type of quark to turn into another type. The explanation for these things is beyond the scope of this article; but the interested reader will find fairly simple explanations in books such as Bill Bryson’s *A Short History of Nearly Everything*.¹⁰

The Four Forces

| The Fundamental Forces | Relative Strength | Effective Range (metres) |
|------------------------|--------------------------|---------------------------------------|
| Strong | 1 unit | 10^{-15} or diameter of the nucleus |
| Electromagnetic | $1/137$ unit | infinite |
| Weak | 10^{-6} unit | 10^{-18} or fraction of a proton |
| Gravity | 6×10^{-39} unit | infinite |

Considering the relative strengths of these four forces we can draw up a table showing the strength and range of each. Electromagnetism and Gravity have infinitely long-range effects, whereas the Strong and Weak Forces only have effects inside atoms.

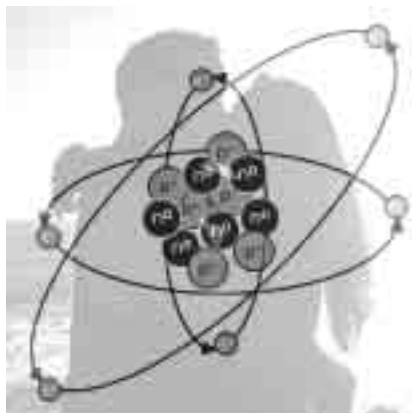
We can now switch our attention to the four different kinds of love.

Eros

C. S. Lewis describes the intense human state of ‘being in love’ as ‘eros’. Eros is the state of desire that grows out of human mating instincts, becoming a state of love in which people constantly hold the object of their love in their thoughts. For Lewis, eros is much more than a physical attraction leading to a physical act: it is a state in which one particular person is desired by another in order to complete the other’s state of being. No one else will satisfy this longing, and separation of two people in a state of eros love causes unbearable pain in both.

It is said that a couple in love are the most selfish two people on earth; no other person is welcome to join them. All the love they have is directed towards the other person and there is none left over to love the rest of humanity. There is a sense in which the couple loses contact with the rest of humanity as the power of the eros attraction totally dominates their existence. Fortunately for the rest of us, couples

¹⁰ Bill Bryson, *A Short History of Nearly Everything* (London: Transworld, 2004).



do not remain 'in love' for too long and they gradually come back down to earth and start to relate as caring human beings as they emerge from their 'falling in love' stage. This does not mean that the couple lose their love for one another, but rather it matures into a different kind of love, suffused with affection and friendship.

Lewis suggests that eros is so powerful that it has a tendency to become like a god totally ruling a couple's existence. In his view eros then becomes demonic and is quite capable of driving those in its grip to carry out terrible acts such as suicide pacts. I am reminded of Bonnie and Clyde,¹¹ who justified their crime spree because they were so much 'in love' with each other.

I see a lot of similarity between eros love in human beings and the Strong Force holding atoms together. Both are very powerful but totally inwardly acting. The priority in physical attraction and emotional love is the exchange of such a strong force that only two particles or two people matter; outside the couple the rest of the universe is disregarded. Like the Strong Force, eros love is only experienced inside the two bodies affected. Eros is the strongest love, yet it has a very short range. If it ceases then the formerly closely bonded bodies fly apart by the forces of repulsion and the partnership comes to an end. Similarly when protons in the heart of the atomic nucleus are freed from the constraints of the Strong Force, they too will fly apart. Therefore I conclude that eros love is the spiritual equivalent of the Strong Force.

Affection

Lewis uses the Greek word *storge*, meaning affection, to describe the gentle love which typically exists between parents and offspring. Affection is born through familiarity and is not confined to a particular type of person—or species. Almost any person can become the object of another

¹¹ Bonnie Parker (1910–1934) and Clyde Barrow (1909–1934) were notorious bank robbers who travelled the USA and were shot dead in a police ambush.

person's affection and this can exist between a man and his dog, between a dog and a cat, or even between a bird and a large animal. It is typically experienced by a group of people, such as the twelve apostles, or by two people who happen to share some history or adventure together. A group of disparate tourists will become bonded in affection for one another because they are sharing a journey or pilgrimage.

It is often said that we choose our friends but not our family, and so it is surprising that we might feel affection for someone who is not at all like us but happens to be tied to us by a set of life's circumstances. Affection means we can learn to have regard, or even love, for someone with whom we might normally be at odds. Growing fond of a geriatric rebel means we begin to appreciate his or her better points and ignore more obvious antisocial behaviour! Affection helps us to reach beyond outward appearance and appreciate the true person within. Affection may lead to loving the unattractive: St Francis of Assisi gives us a good example, hugging lepers because he saw Christ's image within them.

Affection is not the same as being 'in love', where absences quickly become painful; affection can be put to one side and revitalised when the other person returns. But affection can lead to control over others: a mother who does everything for her family may remove her children's freedom of choice, or a patron may decide what is best for his protégé irrespective of his pupil's wishes. When such a 'control freak' misuses affection, then Lewis says it becomes like a demon, leading to broken relationships. For affection to be a positive force it has to be accompanied by something else, usually common sense or a sense of goodness.

The attractive power of affection within a family gives it power to affect the rest of the community. My mother-in-law remembers, as a child in 1920s London, whole families lining up on opposite pavements hurling abuse at each other. Everyone, from the oldest to the smallest, joined in until one of the families slunk off. The affection felt between the members of the winning family turned them into a powerful force in the community. The negative sides of affection, leading to controlling behaviour or emotional blackmail, cause disturbance to other people in the vicinity. The only way to avoid it is to put some distance between the perpetrator and the victims. Similarly the Weak Nuclear Force has very short-range effects and is totally ineffective a small distance away; yet when it is in action it can cause the reactions

that occur inside a nuclear bomb, and it is essential to the fusion processes that cause the sun to burn.

Friendship

Friendship is seldom regarded as a particular kind of love because it is highly selective and ignores factors such as social class, human chemistry and gender. Nearly everyone has at least one friend, even if only the corner shopkeeper where we buy the newspaper. Friendship depends less on *who* friends are but on the common interests they share. Friendships based on such an interest are not limited to two participants but may grow in numbers as others with the same interest want to join in. This is particularly so in recreational activities such as golf or tennis. When the numbers participating in a friendly activity grow then it is companionship rather than friendship that is being shared, until such time as two of the companions discover they have something else in common, over and above what drew them together in the first place, and so a new friendship is born. Lovers are constantly talking to each another about their love, but friends hardly ever need to refer to their friendship. Lovers are always facing each other to express their feelings, but friends are to be found side by side, engaged in a common interest important to both.

The friendship of two people within a group may be seen by the rest as a destabilising factor. The moment two people become friends they have chosen to venture outside the rest of their community. It is advisable not to declare that one person is our particular friend for fear of implying that everyone else present is *not* our friend! Lewis says that friendships are often kept secret, not because they are illicit, but because they are by nature private and hidden from the rest of the community. In fact friendships work best that way.

Friends are not particularly interested in the circumstances of others, such as whether they are married or out of work. Such circumstances eventually become apparent, but it is not they that hold the friendship together; it is the common purpose that friends share which matters most. Lewis believed that friendship depends on two or more people 'see[ing] the same truth'.¹² Two friends instinctively know where the

¹² Lewis, *The Four Loves*, 98.



other is coming from, and an interrupted friendship is effortlessly picked up again and smoothly carried on. In friendship we share who we are with the other person as if we had exchanged our coats or our shoes.

Friendship reminds me of the force of Electromagnetism. The tie of friendship between two people is not sundered by distance; the physical separation might lessen the attraction but it never completely ceases, even when it is at its weakest. The common purpose that friends share reminds me of electricity coursing through a bunch of copper wires forming an electromagnet. It is felt by others outside as a kind of attraction drawing new friends towards them. If the common purpose (the electric current) ceases then the group friendship ceases, unless new common purposes spring up. No outsider wants to join a group that has no common purpose.

Charity

C. S. Lewis writes at length about the human emotions of eros, affection and friendship, and he describes what happens when any of these loves become unduly intense or *inordinate*.¹³ Then a natural human love becomes so important to the functioning of the person and the person desires it so much that it becomes like a god. Eventually it can grow so

¹³ See Lewis, *The Four Loves*, 170.

intense, fuelled by human desires, that it becomes demonic and starts to turn into hatred. I see these three human loves as being of lower spiritual energy and incomplete until they are infused with goodness. Goodness can only come from God and complete love is the true love of God—called, in many translations of the Bible, ‘charity’.

Lewis explains that the three human loves can be rivals to the love of God because they bolster the secret human desire to *be* God. I suggest these natural loves emanate from within our souls and manifest themselves through our emotions, minds and bodily behaviour. But the true love of God communes with our spirit and is God’s love—charity. Charity comes to our spirit through God’s grace and is always there for us if we choose to accept it. Charity knows no limits and brings God’s goodness into our feeble attempts to love one another through the lower loves of affection, friendship and eros. If we were to depend only on these three human loves then our hearts might get broken; but in the presence of charity, God’s grace helps us bear the hurt when human love goes wrong.

The person embracing God’s charity tries to seek God’s image and this is what Jesus means by telling his followers that to love God properly requires them to ‘hate’ their mothers and their fathers (Luke 14:26). The use of the word ‘hate’ is startling, but Jesus means that we need to modify our strong family love or affection by means of charity, which only comes from God, and not from within ourselves. No human love can be equal to the love God has for us. God’s love pervades everywhere and reaches everyone. It is the ‘goodness’ that saves our human loves from becoming selfish and out of control.

Charity can sometimes seem less strong than the other loves, as gravity is less strong than the other forces: Lewis admits that charity may not seem ‘so warm a sensible emotion’.¹⁴ But the greatness of God, like the mass of a planet or the sun, makes this the greatest love of all. I am reminded of Moses’ encountering the full glory of God when he met with God on Mount Sinai (Exodus 19:16–25) or when he entered the Holy of Holies in the ‘meeting tent’. Moses’ face burned from the strength of the energy transmitted by God and his face shone after these meetings. God warned the people not to come too close or they might be killed, such is the awesome strength of God’s power,

¹⁴ Lewis, *The Four Loves*, 170.

particularly in the Ark of the Covenant. Even for Moses looking at God's face was forbidden, and he was permitted to see only the back of God (Exodus 33:12–25). Likewise if the volume of our sun were to be reduced to a few hundred cubic metres then the gravitational field associated with its mass would cause the sun to collapse into a black hole. Such a body would suck into itself all the matter in our solar system by the sheer strength of its gravitational field! Exodus contains many accounts of God meeting the Chosen People accompanied by electrical storms and thick clouds; God's full glory was masked so that it would not harm them.

Loves and Forces

From the parallels that I have drawn between the Four Loves and the Four Forces I conclude that spiritual forces accompany physical forces, jointly holding the universe together. C. S. Lewis concludes that it is only when God's love (charity) is allowed to dominate the three human loves that they come into their own.¹⁵ Scientists instinctively feel that gravitation links the three other Fundamental Forces in a grand unified theory of everything, and it is possible this link will one day become proven fact. They continue to search for the Higgs Boson or 'God Particle'¹⁶ which could explain gravity waves and so prove these combine with the other three forces in one elegant whole.

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¹⁵ See Lewis, *The Four Loves*, 166: 'Even for their own sakes the loves must submit to be second things if they are to remain the things they want to be'.

¹⁶ Named by the Nobel physicist Leon Lederman, because he believed it to bestow 'mass' on all other particles. See Leon M. Lederman and Dick Teresi, *The God Particle: If the Universe Is the Answer, What Is the Question?* (New York: First Mariner, 2006).