

Dan Brown's fantasy

The secret weapon of Dan Brown's book may be lurking out there in space, says S. Ananthanarayanan.

Dan Brown's *Da Vinci Code* created interest in the legends about the life of Christ. Brown's earlier book, *Angels and Demons*, was set in the Vatican City and dealt with the crisis of a piece of *antimatter* falling into the wrong hands. A group of scientists working on data from the INTEGRAL (INTErnational Gama Ray Astrophysics Laboratory) satellite report that they have detected what may be source of antimatter in the centre of the Milky Way.

Antimatter

The idea of Antimatter arose from the work of British physicist, Paul Dirac, to make sense of a class of atom scale particles, like electrons, which show a property called spin, in odd numbers of steps rather than zero or an even number. Dirac built on the work of earlier scientists, the Englishman, W K Clifford and the German, Hermann Grassmann, went deep into Quantum theory and Relativity and came up with an equation that worked for particles like electrons.

Now a feature of the Dirac Equation is that it works not only for the electron but also for a particle just like the electron but with the opposite electrical charge! This puts forward the possibility of a class of particles, the *antiparticles* of the particles described by the equation. It was a major breakthrough that this fantastic prediction was soon followed by the discovery of a particle, called the positron, which was just like the electron, but for the charge! In like manner, we now know of the antiparticles of the proton, the antiproton, or of the neutron, the antineutron, and so on.

Thus, if there can be a negatively charged antiproton and positron, then could there not be an atom of antihydrogen, made up of antiparticles, just like normal hydrogen is made up of the proton and the electron? Well, in principle, yes, and work in CERN and FERMILAB are well into producing antiprotons and antihydrogen in good numbers and at low energies. But even when their facilities are fully operational, they hope to make only 10 million antiprotons a second, which will take 2 billion years to convert into a gram of antihydrogen!

But in principle, with antiprotons, antineutrons and positrons, anti-atoms of all elements are possible and there could be an anti-universe consisting of antimatter, where scientists would research the possibility of a universe like our own. In fact, a question in scientific circles is how could nature choose between particles or antiparticles and there must be a parallel anti-universe!

Annihilation

The way the first, actual positrons were discovered was with gas chamber tracks of cosmic ray particles. What was first thought to be electrons moving the opposite way were recognized as particles with the same mass as electrons but with the opposite charge. These positrons were produced when high energy gamma rays produced pairs of electrons and positrons, which happens when gamma ray photons with energy equal to the rest mass equivalent of both particles interacts with the atmosphere.

The opposite of pair production happens when an electron and a positron come together – they annihilate – with the production of gamma rays! The same should happen when antimatter meets matter – and this has inspired the poem which ends:

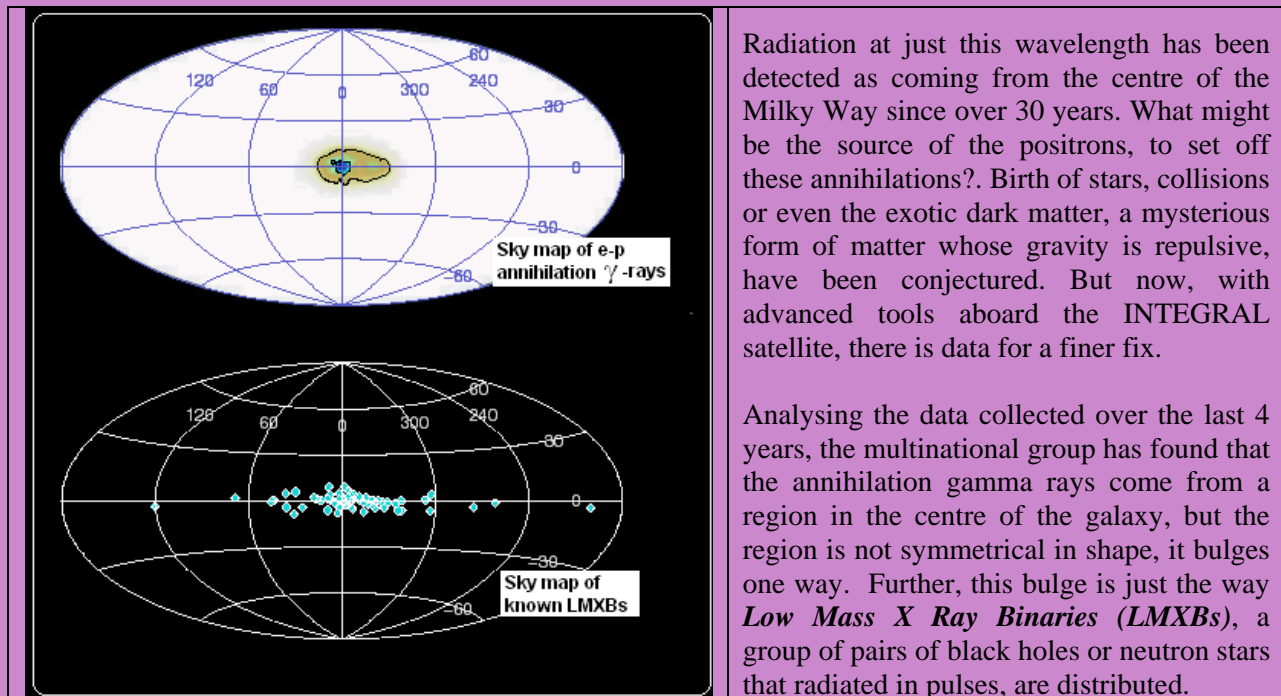
“Then, shouting gladly o'er the sands,
Met two who in their alien ways
Were like as lentils. Their right hands
Clasped, and the rest was gamma rays“

The scale of energy released if antimatter in any quantity could be isolated to interact with matter, of course, would be stupendous. All nuclear energy, including atom bombs, arises from release of a small '*binding energy*', when atomic nuclei rearrange themselves. If the entire matter were to become pure energy, well, just a gram of matter, by the $E=mc^2$ relation, would become something like 21.5 million calories, or the equivalent of 21,500 tonnes of TNT.

We can see why Dan Brown's plot, where a sample of antimatter went astray, could be worked into a feverish race to get it back!

Antimatter in space

When an electron and a positron annihilate, such great energy comes from the mass of the particles that their energy of motion is insignificant. The wavelength of the gamma rays from e-p annihilation is thus quite constant and a good marker, the signature, in fact, of e-p annihilation.



Radiation at just this wavelength has been detected as coming from the centre of the Milky Way since over 30 years. What might be the source of the positrons, to set off these annihilations?. Birth of stars, collisions or even the exotic dark matter, a mysterious form of matter whose gravity is repulsive, have been conjectured. But now, with advanced tools aboard the INTEGRAL satellite, there is data for a finer fix.

Analysing the data collected over the last 4 years, the multinational group has found that the annihilation gamma rays come from a region in the centre of the galaxy, but the region is not symmetrical in shape, it bulges one way. Further, this bulge is just the way *Low Mass X Ray Binaries (LMXBs)*, a group of pairs of black holes or neutron stars that radiated in pulses, are distributed.

The conclusion is that it is these LMXBs that are the source of the positrons that give off the characteristic gamma radiation when they meet with electrons. And there is no need to bring dark matter into the picture!
