The sun in time[1]

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At the Meeting of the American Astronomical Society in Denver, Colorado, held 30 May to 3 June 2004, Dr Ed Guinan of Villanova University gave a brief summary on his long study of 'The Sun in Time'. This was part of session 36: 'The Stellar-Solar Connection: What the stars teach us about our Sun.' His thorough study has centred on identifying solar analogues and twins at various ages in their evolution as determined by their rotation rate (stars spin down with age) and position on evolution tracks in the H–R diagram. He has been observing spectra in the IR, visible, UV, FUV, EUV and X-rays from nearly every recent observatory spacecraft. While I don't accept the absolute ages given by these studies, the results have given both the creationist and evolutionist astronomer some interesting points to ponder. I will list a few of the important results here.

The 'young sun' was much less luminous than our mature sun

Extrapolating back to an age of 130 Myr, the sun would have been 68% as luminous as it is today. Thus, 4.4 billion years ago, the forming solar system would have been a much colder place. For the first billion years, overlapping the time when the first life on Earth (3.85 billion years ago)[2] was supposedly emerging, the sun was at 70% of its present luminosity and the earth would have been a frozen orb, outside the habitable zone of the sun. We know this as the 'Early Faint Sun Paradox', as discussed by Guinan and others over the years.[3]

Carl Sagan was noted for his posthumous publication with Chyba of a supposed solution to this problem,[4] involving ammonia as a greenhouse gas with a methane smog to protect the ammonia from photodissociation in the young earth's atmosphere. Pavlov *et al*.[5] also used methane as a greenhouse gas to try to explain the paradox effect. However, regarding such models, Danny Faulkner, a noted creationist astronomer, states:

> 'The precise tuning of this alleged co-evolution is nothing short of miraculous. The mechanism driving this would have to be a complex system of negative feedbacks working very gradually, though it is not at all clear how such feedbacks could occur.'[6]

The 'young sun' was extremely active

Observations by Guinan of solar analogues EK Dra and 47 Cas showed 28 violent flares in a 7-day observing run, with energies of 10^{33}–10^{35} ergs.[7] These flares were 100–1,000 times stronger in the EUV than the sun's flares and displayed coronal plasmas with temperatures of 20–30 million degrees Kelvin—nearly twice as hot as the core temperature of the sun. Working from these analogues, the 'young sun' would have had 2–5 such violent flares per day!

This enhanced activity is due to the action of the excessively fast rotation of young stellar dynamos. The rotation rates are on the order of ten times faster than our present sun, which has a rotation rate of about 28 days. The X-ray emissions of the 'young sun' would have been about 100 times stronger, and the solar wind density 500–1,000 times as massive, causing it to lose about 2% of its mass in its early life. The mass loss for our sun at an age of 100 million years, as determined from young solar-analogues, is 200–10,000 times its present rate.[8] The resulting solar wind would erode a planetary atmosphere by sheer aerodynamic drag. And the X-ray, EUV and FUV emissions would cause disastrous photochemical effects, photoionizing the atmosphere and stripping away the ionosphere.

This erosion is believed to have not only ablated Mercury's atmosphere, but eroded its crust and much of its mantle, leaving little of its original material overlying its iron core (which is nearly the same size as Earth's). Due to its proximity to the sun, a tiny amount of ablation of Mercury is occuring today as indicated by recent observations. On Mars, solar erosion apparently did not start until it lost its magnetic shield (estimated to have occurred at least 3.9 billion years ago).[8] As the result of the loss of the magnetic shield, any water on Mars would have dissociated, with the hydrogen escaping out of the atmosphere and the oxygen being absorbed by the rocks, giving them their red colour.

Only the young earth's very strong magnetic field could have halted much of the solar wind's destructive activity. But heavy auroral activity and electromagnetic storms would have been the order of the day. The ozone levels would have reached very high values, further cooling the surface temperature, and the high-energy photons discharged by the sun could have had devastating effects on the upper atmosphere. Guinan[9] hopes that the photochemical effect of the fantastic X-ray and UV irradiance of the earth would influence the methane abundance favourably to aid Sagan and Chyba's[4] and Pavlov *et al*.'s[5] weak models, but no details have been provided for such a process.

An interesting question was asked by one astronomer at the meeting. After commenting on the evidence for magnetic field polarity reversal, he asked, 'What would happen to the earth when the magnetic field was zero or near zero during its regular oscillations? Would not that leave the earth unshielded from the fantastic flaring and the dense coronal-mass emissions of the young sun? Would that rip away the atmosphere and boil away the oceans, etc.?' He was answered with a statement something like, 'Well, we still have an atmosphere and oceans so I suppose it did not!' Regardless, the frequent collision events called for by geophysicists prior to 3.2–3.5 billion years ago[2,10] make the prospects for life gaining a foothold bleak.

Currently observed analogues of the 'young sun' have variabilities of 3–4% at the very least compared to the sun's 0.1% variability. All this shows that our sun has 'apparent age'; it is a mature, quiet star able to sustain and nourish life on Earth.

The sun is unique

The sun has been promoted as an average, ordinary star. However, among stellar populations it is in the 99th percentile for its mass, and as more dwarf stars near the stellar limit become known it may well end up in the 99.9th percentile! It is not a mundane, ordinary star. If it were a very average star, you would expect there to be many solar analogues (stars broadly similar to the sun). However, for a start, the vast majority of stars appear to have stellar companions, which sets the sun apart, as the variations within a binary system are unlikely to be favourable to life. After extensive searches for solar-like stars among multiplied thousands, only a few candidates have emerged, and only one star, 18 Sco, nearly matches the spectral and irradiance characteristics of the sun. Its night-to-night variation in brightness is only ~0.3%, similar to that of the sun, but 18 Sco's chemical abundance pattern of some 25 elements is decidedly non-solar. It is also somewhat displaced upward from the sun on the H–R diagram, making its supposed age about six billion years.

Ages of stars may be statistically determined by their velocity, and stars are thought to pick up kinetic energy from clouds of dust and gas that swarm past them. However, the sun has a decidedly low velocity with respect to the Local Standard of Rest (the average motion of nearby stars). And furthermore, the sun's low surface abundance of lithium does not match up with its rotation age. Among 100,000 normal stars it has been estimated that there are less than five solar analogues, with varying degrees of similarity.

The sun is exceptionally stable

The sun has a weak (0.1%) variability through its 10- and 12-year bimodal sunspot cycle and perhaps up to a few tenths of a percent in short-term variations due to dark spots and faculae (hot white regions). The Sun is in a very quiet region of the H–R diagram and is exceptionally stable. As Dr Radick asks, 'Why is the sun so smooth?' And further, 'Is the sun just well behaved?'[1]

As creationary scientists and Christians, we know why the sun is so well behaved; because it was created to provide life-giving warmth to the earth and its inhabitants.

> 'For thus says the LORD, Who created the heavens, Who is God, Who formed the earth and made it, Who has established it, Who did not create it in vain, Who formed it to be inhabited: I *am* the LORD; and *there is* no other [Isaiah 45:18].'

References

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