Sun's encounter with star predicted

The Solar System proper seems safe from external calamity for the next 50 years, but there is a danger that a close encounter with α Centaurus A/B could shake loose a shower of comets on the Earth.

THERE is, no doubt, widespread relief that Comet Swift-Tuttle is not now believed likely to collide with the Earth on its next-but-one return, in 2126 (see *Nature* 367, 681; 1994). But before rejoicing gets out of hand, the world should know of a potentially more serious threat to its peace of mind — the prospect that there will be a veritable shower of comets crossing the Earth's orbit in the million or so years following the next close encounter of the Solar System with another star, likely to take place 30,000 years or so from now.

This calculation is due to Robert A. J. Matthews, who divides his time between research and as a science writer for the London newspaper *The Sunday Telegraph*, and is published in the current issue of the *Quarterly Journal of the Royal Astronomical Society* (35, 1–9; 1994). Matthews has worked out the probable motion of some of the stars known to lie within 5 parsecs of the Sun. His immediate objective is to tell which of several is likely to succeed Proxima as the Sun's nearest neighbour. The arithmetic is not as simple as might be expected.

Proxima itself is a dwarf star, perhaps 10 per cent the mass of the Sun. From time to time, there are flares on its surface, suggesting (but not proving) that it is relatively young. Its present distance from the Sun, inferred from parallax measurements (of its position relative to more distant stars from opposite ends of the Earth's orbit) is 1.295 parsecs. (One parsec is the distance at which the Earth's orbit would subtend an angle of one second of arc; numerically, it is 206,000 astronomical units, where one AU is the radius of the Earth's orbit about the Sun.)

Listing nearby stars is not child's play. Brightest is not necessarily nearest; only parallax can settle that. But there seem to be 58 stars within a 5 parsec radius of the Sun. To know the present velocity of a star, two other measurements are required; its radial velocity and its angular motion across the sky, otherwise its proper motion.

Sadly, these measurements of Proxima cannot be used to extrapolate its future motion relative to the Sun because of a pre-existing difficulty, that of knowing whether Proxima is a free agent or, otherwise, the third member of the binary system known as α Centarus A/B, a binary star in which each component is as massive as the Sun and only a little further away than Proxima at 1.335 parsecs.

Published data, according to Matthews, cannot decide whether Proxima is free or bound. Whatever the truth, it can only be marginally captive. The distance between Proxima and α Centaurus A/B leads to a lower limit for the semi-major axis of its presumed orbit about the binary of 13,000 AU; similarly, the period of rotation must be at least one million years.

For what it is worth, Matthews says he has been convinced by unpublished data from the European Southern Observatory's measurements of radial velocities at La Silla in Chile that Proxima is indeed bound, which raises an interesting conundrum. The two stars of the binary are main-sequence stars, probably more ancient than the Sun. One possibility is that they began life as a triple star, the other is that the binary has more recently captured Proxima. Given the flares on Proxima, capture is the more likely origin.

Either way, the notion that Proxima is indeed bound into a triple star makes it possible to correct its radial velocity and to make a more accurate extrapolation of its motion than would otherwise be possible. The upshot is that Proxima will be closest to the Sun 26,700 years from now, at a distance of 0.941 parsec. What effect, if any, will that close passage have on the Solar System?

This is where the binary comes into its own. Wherever Proxima is in the future, α Centaurus A/B will not be far away. Moreover, the mass of the binary is some 20 times that of Proxima and thus likely to be much more influential. But for the record, it is worth noting Matthews' conclusion that during the next 50,000 years at least three other stars (Barnard's star, Ross 248 and AC + 79° 3888) will, in that order, come within a parsec or so of the Sun. Indeed, Matthews says "we are approaching a time peculiarly rich in stellar encounters" when near-approaches to the Sun will be ten times more frequent than expected from the distribution of stars in the Galaxy.

The effects of α Centaurus A/B on the Solar System will not at first be dramatic. For one thing, there will be no perceptible disturbance of the planets, which all lie comfortably within 50 AU of the Sun. Such effects as there will be will involve the so-called Oort cloud of proto-comets believed to lie beyond the planets but within a radius of less than half a parsec (say, 100,000 AU) of the Sun. The passage of α Centaurus A/B could set calamitous events in train there.

That the Oort cloud, which commands

varying degrees of belief and scepticism, exists is no longer in dispute; the difficulties lie in the estimates of the number of proto-comets it contains and, more pertinently for the effects of the near-encounter with α Centaurus A/B 30,000 years or so from now, the distribution of proto-comets with distance from the Sun. There is no shame in that, as can be told from how the population of the Oort cloud was first painstakingly estimated from records of comets in nearly, but not quite, unbound (or 'hyperbolic') orbits.

The physics of the near-encounter with α Centaurus A/B is simple. The star would provide each proto-comet with a mechanical impulse, which can be calculated from the trajectory of the star and the supposed distance of the proto-comet. Matthews concludes that the projected approach of α Centaurus A/B will shake loose 200,000 comets from the Oort cloud, providing them with at least the potential to move within the Earth's orbit around the Sun. But a substantial fraction of those would be ejected from the Solar System altogether by unfavourable encounters with Saturn and Jupiter, although others would become more or less permanent Earth-crossing comets. It is worth noting that the total Oort population, estimated at a small multiple of 10^{12} proto-comets, would not be substantially diminished by the encounter.

Luckily, the timescale of this process is not short. The orbital period of an Earth-crossing comet created by impulsive perturbation of a proto-comet in the Oort cloud at 100,000 AU would be about a million years. Other objects able to threaten the Earth by impact, perhaps by interaction with Neptune and Uranus or Saturn and Jupiter would become perils only after an interval ten times as great. In other words, there is time in hand.

That raises an absorbing question. The close encounter with α Centaurus A/B 30,000 years from now will take place only after the passage of 100 times as much time as there has been since Galileo first saw the motion of the moons of Jupiter. It is not easily conceivable that the people then practising astronomy will not have figured out in detail what the Oort cloud consists of. It is not inconceivable that its proto-comets will have been recorded in some database. In other words, the prospect of calamity will be an operational problem. Is that what Spring holidays are about?

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