within-host selection for faster reproducing strains will increase parasite virulence and maintain genetic diversity, at the cost of reduced transmissibility (M. Nowak, Univ. Oxford).

To increase survival within hosts, some viruses, such as the human immunodeficiency virus, have evolved high mutation rates. The consequence is the generation of rare genotypes which have temporary advantages in the frequency-dependent race with the host immune response (A. Leigh Brown, Univ. Edinburgh). This high mutation strategy may be disadvantageous to both host and parasites if the within-host competition leads to increasingly higher virulence and rapid death of the host[6]. But it can also generate synergistic evasion strategies of the host immune system, which require epitope variability to operate[7].

High rates of generic change — through mutations, sexual recombination or both — characterize host–parasite coevolution. Genetic diversity provides the ammunition in this arms race, in which parasites evolve in a constant conflict of within and between-host selection, and hosts are under constant pressure to escape their parasites. Whether or not sex is crucial in this race remains one of the most exciting questions in biology. □

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INTERPLANETARY DUST

The ring around us

Donald E. Brownlee

ONE of the Solar System's great failures was its inability to assemble a full-scale terrestrial planet between Mars and Jupiter. The orderly fabrication schedule of what would have been the fifth terrestrial planet was rudely interrupted by the rapid and nearby formation of Jupiter. Today, all that remains of this process is the asteroid belt, a collection of relict planetary building blocks up to 1,000 km in diameter.

Following an initial period of growth, the main-belt asteroids have endured aeons of destructive collisions that slowly but relentlessly pulverize them. As dust particles are generated they migrate towards the Sun, forming a thin particle sheet whose radial distribution can be strongly influenced by the gravitational pull of the planets. On page 719 of this issue, Dermott *et al.*[1] suggest that perturbations by the Earth stall a portion of the inflow to produce a circumsolar dust ring centred just beyond the Earth's orbit. The ring has peculiar azimuthal fine structure, with a gap that the Earth resides in and a dust concentration that trails the Earth like a shadow as it orbits the Sun.

The origin, evolution and destruction of dust in our Solar System and in other circumstellar dust systems are a complex set of processes[2]. Interplanetary dust originates from comet sublimation, asteroid collisions and direct injection of interstellar dust from the Galaxy[3]. It is removed by ejection from the Solar System, collision with other particles, accretion onto planets or evaporation near the Sun. The timescales for these processes are short, and individual 10-μm particles survive in the inner Solar System only for about 10^4 years.

One of the key cleansing features in the Solar System is the Poynting – Robertson (P–R) effect[4], the orbital decay of small particles due to the drag component of sunlight pressure. This is a universal process that occurs for all orbiting particulates where absorbed and scattered photons yield a net drag force against a particle's motion. For a 10-μm particle, this effect produces an inwards spiral of about one Earth radius per year at a distance of 1 AU from the Sun. The effect drives particles towards the Sun where they are vaporized or fragmented by collisions, in which case their debris may be driven out of the Solar System by radiation pressure as beta meteoroids[5]. As particles spiral inwards from the asteroid belt they can be temporarily trapped in resonances that stop orbital decay[6]. Simulations have shown that particles of the appropriate size can be trapped for times as long as 100,000 years, although this is a highly stochastic process and many particles escape without significant trapping.

Resonance trapping by the Earth occurs when a particle orbit decays to a location where its orbital period is a simple fraction (6/5, 7/6 and so on) of a year. Quasi-stable trapping occurs at these locations because close resonant encounters with the Earth add sufficient orbital energy to a particle to counteract the constant energy loss from P–R drag. As viewed from a Sun-centred reference frame that co-rotates with the Earth, the path of a trapped dust particle is an epicycloid with multiple loops approaching the Earth's orbit at the particle's closest approach to the Sun.

Orbital calculations by Jackson and Zook[6] suggested that the stalling of asteroid dust in the many resonances just outside the Earth's orbit could result in a dust ring. Numerical simulations by Dermott *et al.* back this up and, in addition, they show that structure in the ring leads to an asymmetry in the concentration of dust leading and trailing the Earth in its orbit about the Sun. Resonances with different orbit-period commensurabilities all have the common property that one of their epicycle loops occurs just behind the Earth, producing a dust concentration there. Just in front of the Earth there is a gap in the ring, but elsewhere the ring is relatively uniform because epicycle loops of various resonances are out of phase. The predicted variations of dust density just leading and trailing the Earth are quantitatively consistent with asymmetry seen in the infrared brightness of the zodiacal light in these directions as measured by the IRAS spacecraft.

One of the interesting predictions of this model is that transfer of trapped asteroidal particles to the Earth will have annual variations. Because of its orbital eccentricity, the Earth drifts within the gap in the ring and near the end of each year it lies closest to the trailing dust cloud where enhanced accretion of asteroid dust can occur. This annual enhancement of asteroid dust should show up in the micrometeorite collections routinely made in the stratosphere. One of the goals of collecting stratospheric micrometeorites is the identification of cometary and asteroidal materials, and this yearly variation may provide an important criterion for distinguishing between particle types. Rietmeijer[7] has already found evidence for temporal changes in particle types that might be due to such annual variations. And finally, looking further afield, rings of resonantly trapped dust undergoing P–R drag might be a clue to otherwise undetectable planets in the dusty disks that commonly surround other stars[8]. □

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