Supernovae and life

SIR — We call attention to synchrotron radiation emanating from supernovae as a source of circularly polarized light capable of inducing asymmetric photochemical reactions of prebiotic molecules. This light is predominantly polarized in the plane of motion of fast electrons orbiting around supernovae and when viewed off-axis the polarization is elliptical or circular. Chiral molecules in the interstellar medium or on planetary surfaces would undergo preferential photosynthesis or photolysis when irradiated by such a source. Domains on opposite sides of the plane of predominant polarization would be exposed to light of opposite helicity so that overall symmetry would be preserved. But in a single locale, one enantiomer would predominate.

Molecular chirality can be approached either as an expression of random fluctuation or as the result of a specific mechanism. Mann and Primakoff point out that statistical fluctuation as the basis of chiral dominance is highly unlikely because it would require the assumption of a very small number of terrestrial polymerization sites[1]. The physical processes that have been invoked include the interaction of a racemic mixture with electrons of specific helicity emitted by a nuclear β-decay process, and the apparently more effective interaction of circularly polarized light (CPL) with molecular orbitals. Photosynthetic and photodestructive reactions with CPL have been described in a number of reviews, and a 2.50% optical enrichment of a racemic mixture of the amino acid leucine has been achieved by photolysis with 212.8-nm CPL[2].

The sources of CPL previously considered include sunlight reflected at the Earth's surface, and by the Earth's magnetic field[2]. Alignment of interstellar grains has also been identified as a source of linear polarization, and a phase shift can lead to circular polarization[3]. These mechanisms require two independent processes: scattering or preferential absorption, followed by optical rotation in a birefringent medium of well-defined optical axis and proper optical thickness.

Synchrotron radiation is also an important source of CPL. The history and the properties of synchrotron radiation have been recently reviewed by Winick and Doniach[4]. Liénard first discussed the concept of radiation from a charged particle moving circularly. Sokolov and Schwinger provided theoretical treatments and Pollock and his colleagues made some of the early experimental studies.[4].

Shklovskii suggested that the continuous light from the Crab Nebula arises from the synchrotron process, Dombrovskii demonstrated that the light is polarized, and detailed studies in the optical range were undertaken by Oort and Walraven and by Baade[5]. These investigations showed that electrons are continuously ejected by the supernova remnant and that the synchrotron radiation persists after the initial explosion. Although stable polarization is a characteristic of some sources, in others there are fluctuations and multiple components.

A number of lines of astrophysical evidence link supernovae to the formation of planetary systems[6]. The intensity, the spectrum (extending into the X-ray region), and the high degree of polarization, including circular polarization, of supernova synchrotron radiation, indicate that this light is capable of processing polyatomic molecules in nearby interstellar matter, leading to asymmetric photosynthesis or photolysis in out-of-plane domains. The circular polarization is a direct effect that does not require fortuitous alignment of consecutive optically active media.

For life to arise from chiral building-block molecules modified by synchrotron light, it would be necessary for these either to survive intact during the heating process of planet formation or to be ferried on incoming grains as the planet periodically traverses clouds of interstellar material or to be assembled on tepid planetary surfaces illuminated by residual supernova synchrotron radiation.

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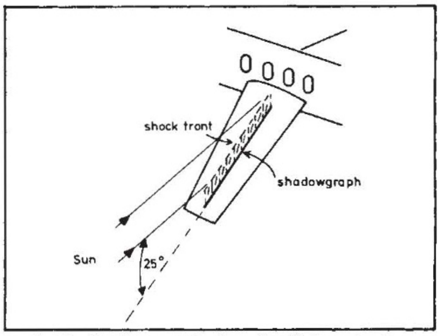
1. Mann, A.K. & Primakoff, H. *Origins of Life* (in the press).
2. Flores, J.J., Bonner, W.A., & Massey, G.A. *J. Am. Chem. Soc.* **99**, 3622-3624 (1977).
3. Savage, B.D. & Mathis, J.S. *A. Rev. Astron. Astrophys.* **17**, 73-111, (1979).
4. Winick, H. & Doniach, S. in *Synchrotron Radiation Research* (eds Winick, H. & Doniach, S.) 4-6; 11-25 (Plenum, New York, 1980).
5. Baade, W. *Bull. Astron. Instit. Netherlands* **12**, 312 (1956).
6. Herbst, W. & Assousa, G.E. *Scient. Am.* **241**, 138-145 (1979).

In-flight movies

SIR — Shadowgraphs provide a simple method of studying aerodynamic shock waves, but I was unaware until recently that striking shadowgraph patterns may sometimes be seen on the wings of civil aircraft. I understand that this phenomenon is wellknown within the aerodynamic fraternity but my observations may interest others who, in the spirit of Jearl Walker[1], have a taste for science outside the laboratory.

At cruising altitude, the flow over the leading edges of the wings of conventional airliners is accelerated to trans-sonic speeds. This may give rise to shock fronts which stand perpendicular to the wing-surface along its span, and extend upwards for 1 or 2 metres. Light traversing the shock at glancing incidence is refracted towards the trailing edge of the wing and may produce a shadowgraph. Lamplough[2] has demonstrated this effect in flight using collimated light from an artificial source directed parallel to the wing-surface.

I recently observed similar shadowgraphs cast by natural sunlight while flying at an altitude of about 10^4m in a Boeing 727. The shadow-band extended in an almost straight line along most of the width, as sketched in the diagram, and I estimated its width (by comparison with rivets) to be roughly 1-2 cm. A narrower bright band, akin to a caustic, lay along the rear boundary of the shadow. The pattern was of moderate to low contrast seen against the sunlit wing surface, and it remained visible for more than an hour showing that the angle of illumination was not critical. The Sun was at an elevation of some 20°-30° above the wing-tip. The pattern occasionally jumped irregularly fore



and aft during periods of mild turbulence and multiple bands were sometimes seen. As the aircraft descended, the pattern shifted steadily towards the leading edge of the wing, fading and narrowing until it disappeared. This behaviour is consistent with a weakening shock due to reduced air speed.

In typical conditions, the Mach number of the flow might change from 1.3 to 0.9 across the shock, producing a jump in density of about 0.1 kg m^{-3} and a corresponding increase in refractive index of about 2×10^{-5}. Light traversing the shock at glancing incidence will be refracted through an angle of roughly 0.4° which is comparable with the angular size of the Sun; appreciable blurring of the shadowgraph may thus be expected. The width of the observed pattern showed that in my case the shock must have extended about 1 m above the wing.

High-flying observers wishing to see these effects and unacquainted with the characteristic appearance of shadowgraphs are recommended to consult photographs such as Figs 223 and 224 of ref 3. I am indebted to Dr P.J. Bryanston-Cross for illuminating discussions about trans-sonic flow near aerofoils.

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1. Walker, J. *The Flying Circus of Physics* (Wiley, New York; 1975).
2. Lamplough, A.E. *Aircr. Engng* **23**, 94 (1951).
3. Van Dyke, M. *An Album of Fluid Motion* (Parabolic Press, Stanford, 1982).

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