# Polarized Stellar Light

In their report "Circular polarization in star-formation regions: Implications for biomolecular homochirality" (*1*), Jeremy Bailey *et al*. state that circularly polarized ultraviolet light is not to be expected in the region of a young supernova remnant, such as the Crab Nebula. They cite Roberts, who maintained that the distribution of pitch angles of the electrons will cancel out circular polarization of high-frequency radiation (*2*). However, circularly polarized synchrotron radiation will be emitted along the axis parallel to the magnetic field, with frequencies that are small integer multiples (harmonics) of the cyclotron frequency $\omega_c = ecB/E_e$, where $e$ is the electron charge, c is the speed of light, $B$ is the magnetic field, and $E_e$ is the total relativistic electron energy (*3*). The photon energy $E_p$ at the $n^{th}$ harmonic is then $E_p = en\hbar cB/E_e$, where $\hbar$ is Planck's constant/2 $\pi$. Thus, for photons of 6 eV, which are known to be effective for photolyzing amino acids, and for electrons of 60 MeV volts, $B$ is of the order of $6 \times 10^{10}$ G. The magnetic field of neutron stars has been estimated to be up to $10^{12}$ G (*4*).

Because the optical synchrotron radiation from the Crab Nebula has been observed to be 40 to 60% linearly polarized and as much as 0.03% circularly polarized, and its 1415-MHz radiofrequency radiation to be as much as 0.05% right circularly polarized (*5*), it is clear that circularly polarized ultraviolet synchrotron radiation must also be present.

The argument of Bailey *et al*. (equally applicable to their mechanism) that circularly polarized synchrotron radiation would be ineffective for an enantioselective radiolysis of amino acids is based on the conclusion of Mason (reference 13 in the report) (*6*) that the "Kuhn-Condon zero sum rule" for circular dichroism bands precludes such effects. This apparent misinterpretation of the Kuhn-Condon rule has recently been corrected (*7*).

**Edward Rubenstein**
*Department of Medicine,*
*Stanford University School of Medicine,*
*Stanford, CA 94305, USA*
*E-mail: exr@leland.stanford.edu*

**William A. Bonner**
*Department of Chemistry,*
*Stanford University,*
*Stanford, CA 94305, USA*
*E-mail: wbonner@leland.stanford.edu*

**George S. Brown**
*Department of Physics,*
*University of California, Santa Cruz,*
*Santa Cruz, CA 95064, USA*
*E-mail: gsbrown@cats.ucsc.edu*

**References**

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*Response:* Rubenstein *et al.* state that "circularly polarized synchrotron radiation will be emitted along the axis parallel to the magnetic field." This is correct, however, only for low electron energies (cyclotron radiation, as observed astronomically in the AM Herculis binaries or Polars, which have high optical circular polarization). In the highly relativistic case (synchrotron radiation), relativistic beaming means that radiation is not emitted parallel to the magnetic field. The radiation is beamed into a narrow cone around the direction of particle motion (that is, perpendicular to the magnetic field), and predominantly linear polarization is produced.

The quoted figure of 0.03% circular polarization for the optical emission from the Crab Nebula is an upper limit. Circular polarization was not observed (*1*). Subsequent more sensitive work measured small levels (about 0.1%) of circular polarization, but we attributed these results to birefringence resulting from aligned grains in the interstellar medium; we found nothing intrinsic to the nebula (*2*).

The 0.05% polarization at 1415 MHz is a small polarization at a frequency a million times less than the circular dichroism bands of interest. The available observations at optical wavelengths (within a factor of 2 of the ultraviolet circular dichroism bands) do not show significant circular polarization. The lack of circular polarization instrumentation in space, however, means that there have been no direct observations at the wavelength of interest.

Rubenstein *et al*. also dispute the conclusion by Mason (*3*) that broad-band circularly polarized light cannot be enantioselective. While there may not be complete cancellation, as Mason has stated, there is still likely to be substantial reduction in the enantiomeric excess that can be generated if the spectrum covers bands of alternating sign, as is likely to be the case with a spectrum such as that of the Crab Nebula, which extends into the far ultraviolet and x-ray regions of the spectrum. The problem is much less serious for our mechanism, which uses scattered starlight, because the spectra of most stars falls off steeply below 200 nm, which limits absorption to the longest wavelength circular dichroism band.

**Jeremy Bailey**
*Anglo-Australian Observatory,*
*Post Office Box 296,*
*Epping, New South Wales, 2121, Australia*
*E-mail: jab@aaoepp.aao.gov.au*

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