LETTERS

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

Crisis for Biodiversity Collections

ALTHOUGH WE AGREE WITH DONALD Kennedy about the importance of seed and other germplasm collections ("Agriculture and the developing world," Editorial, 17 Oct., p. 357), and we support the efforts of the Global Conservation Trust and the Consultative Group on International Agricultural Research to preserve these collections, many other critical biodiversity collections are facing challenges as well (*1*, *2*). The biological collections in natural history museums and herbaria also serve vital roles in protecting sustainable agriculture, including the identification and mitigation of invasive alien species, and enabling biological control. When the cassava mealybug threatened collapse of the staple diet of millions of Africans (*3*), successful biological control was achieved only after in-depth research on classification (systematics) with museum collections. These collections also allow identification of disease vectors and pollinators, document ethnobotanical practices, and support a vast array of other uses (*4*). Museum collections have a set of globally agreed-upon plans of action, including the Global Taxonomy Initiative and Global Strategy for Plant Conservation of the Convention on Biological Diversity, and the Global Biodiversity Information Facility (*5*), but international investment has been insufficient. It is ironic that, just as the U.S. National Science Foundation increases funding for biodiversity research, many states are threatening to discontinue support for their collections (*6*).

> **"It is ironic that, just as the U.S. National Science Foundation increases funding for biodiversity research, many states are threatening to discontinue support for their [biodiversity] collections."**
>
> —*MILLER* ET AL.

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Synchrotron-Čerenkov Radiation

IN HIS NEWS FOCUS ARTICLE "MONEY SPINNER or loopy idea?" (12 Sept., p. 1463), Edwin Cartlidge reports on a conjecture that energy radiated by a charge in uniform, superluminal, circular motion would vary as $1/r$, rather than $1/r^2$, in the far zone. Such radiation combines features of synchrotron radiation (due to a charge in uniform circular motion) and Čerenkov radiation (due to a charge with superluminal velocity). This topic has been analyzed theoretically by Erber, Schwinger, and others (*1*–*9*), where it is predicted that the far-zone radiation pattern falls off as $1/r^2$, as must be the case for any energy-conserving radiation pattern emitted by a real, and hence spatially bounded, source. Observation of an interference effect between the synchrotron and Čerenkov components of such radiation has been reported by Bonin *et al.* (*10*).

An infinite line source could, mathematically speaking, emit cylindrical waves whose energy varies as $1/r$, as measured from the axis. But any real source with cylindrical symmetry must have a finite extent along its axis, and for distances that are large compared with the size of the source, the radiated energy falls off as $1/r^2$, as required by consistency with the laws of diffraction and conservation of energy.

Superluminal motion leading to radiation can be achieved by a single charge moving with velocity $v < c$, where c is the speed of light, in a medium of index of refraction n such that $v > c/n$ (Čerenkov radiation). Effective superluminal motion can also be achieved when an extended beam of charged particles, each moving with velocity $v < c$, intercepts a surface such that the point of contact moves with velocity $u > c$. An example of the latter is the electron beam in a Tektronix 7104 oscilloscope, whose "writing speed" can exceed c. In this case, the transition radiation that is emitted as the beam enters the surface of the oscilloscope faceplate takes on the character of Čerenkov radiation (*11*). If the oscilloscope were rotated about an axis perpendicular to that of the electron beam, the configuration would be that discussed in the article and so would produce synchrotron-Čerenkov transition radiation—with a $1/r^2$ falloff of the radiated energy.

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Response

THE ELECTROMAGNETIC FIELD ASSOCIATED with the vacuum version of synchrotron-Čerenkov radiation, i.e., the field generated by a superluminally rotating point source, has an infinitely large amplitude on the envelope of the emitted wave fronts, which is a surface extending from the source to the far zone (*1*). McDonald's contention that the intensity of this radiation is everywhere finite and decays like the inverse square of the distance from its source stems from a misinterpretation of the published analyses that he refers to, none of which are performed in the time domain. For the same reason that the singularity of a Dirac delta function cannot be directly inferred from an individual Fourier component of this function (which equals 1), the divergence that arises in the vacuum version of synchrotron-Čerenkov radiation is concealed by any analysis that is solely performed in the frequency domain (*2*, *3*).

Sources that move with a speed faster than that of light in vacuo cannot, of course, be pointlike (*4*). However, when the contributions arising from the constituent (pointlike) volume elements of an extended source are superposed, the divergence in question endows the resulting radiation field of a volume source with a (singularity-free) intensity that decays like $1/r$, instead of $1/r^2$, with the distance r from the source (*1*, *3*). This result, which is a mathematically rigorous consequence of the retarded solution of Maxwell's equations, does not disagree with those referred to by McDonald. The individual Fourier components of the field that is generated by an individual volume element of any of our extended sources agree with those that are derived in the context of synchrotron-Čerenkov radiation, and each exhibit the Airy-function oscillations (characteristic of the intensity fluctuations near caustics) that are observed by Bonin *et al.* (*5*). [There is, however, a fundamental difference between the radiation processes involving caustics in vacuum and in a medium: For high enough frequencies, the phase velocity of light in a medium will approach the velocity of light in vacuo and so will smooth out any sharp gradients in the field, but in the case of sources that move superluminally in vacuum, there is no agent to eliminate the singularities that appear in the field of a point source (i.e., in the Green's function for the radiation process).]

Nor is there a discrepancy between our results and the requirements of the conservation of energy. The focused wave packets that embody the nonspherically decaying pulses are constantly dispersed and reconstructed out of other waves, so that the constructive interference of their constituent waves takes place within different solid angles on spheres of different radii r [appendix D of (*1*)]. The integral of the flux of energy across a large sphere centered on the source is the same as the integral of the flux of energy across any other sphere that encloses the source. The strong fields that occur in focal regions are compensated by weaker fields elsewhere, so that the distribution of the flux of energy across such spheres is highly nonuniform and r dependent.

Finally, the superluminal source that is produced by the impact of an electron beam on the face plate of an oscilloscope does not correspond to the configuration discussed by Cartlidge in his article. The superluminal effects described in the report only arise from a volume-distributed source, from one in which there is an extended dense set of source points that approach the observer with the speed of light and zero acceleration at the retarded time (*1–3*).

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