Two-Photon Decay of Metastable Hydrogenic Atoms

In a recent review of beam-foil techniques, Metz (*1*) discussed the work of Marrus and Schmieder (*2*) on the two-photon decay of the metastable $2^2S_{1/2}$ state in Ar XVIII. In this discussion Metz stated that they ". . . have confirmed the applicability of the nonrelativistic theory of quantum mechanics to the description of a particularly long-lived state in one-electron argon." While this is correct, it should be noted that all the essential features of the theory of the decay of this state of hydrogenic atoms were verified by the present author and his colleagues many years ago in a series of experiments on the helium ion. This work culminated in the first observation of two-photon spontaneous emission.

In 1965 (*3*) we reported on the direct detection of the two-photon emission with a photon-coincidence-counting technique. In this experiment a slow beam (12 ev) of metastable ions was viewed in vacuum by two high-speed photon detectors. Coincidences were observed between the two detectors, and the angular correlation of the coincident photons was observed. The electron bombardment excitation threshold for the state producing the coincidences was shown to be 65 ev, as was expected for the $2^2S_{1/2}$ state of He^+. It was also shown that if microwave transitions were induced from the metastable $2^2S_{1/2}$ to the short-lived $2^2P_{1/2}$ state, the coincidences disappeared, which confirmed that they arose from the long-lived $2^2S_{1/2}$ state. As indicated above, this experiment completely established the two-photon nature of the decay of the hydrogenic metastable state of the helium ion and was, in fact, the first observation of spontaneous two-photon emission. In later work (*4*) the spectrum of the two-photon emission was studied. While this work was limited by counting statistics, we were able to establish the gross features of the two-photon spectrum. These observations and a general review of the entire problem of the metastable hydrogen atom have been published (*5*).

In 1962 (*6*) we showed that the population of metastable helium ions decreased by 20 percent during a 400-μsec transit in an ion beam apparatus. This showed that the lifetime of the state is about 2 msec, in excellent agreement with the theoretical value of 1.9 msec predicted by Breit and others (*7*). This apparatus has been completely rebuilt, and C. Kocher, J. Clendenin, and the author are presently making observations on the lifetime that should yield a result with an accuracy of 1 percent.

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8 May 1972; revised 14 June 1972

Eye Marks in Vertebrates as Aids to Vision

Ficken, Matthiae, and Horwich (*1*) have put forward the suggestion that the patterns of lines and circles around the eyes of various vertebrates may serve as aids to vision. In particular, they suggest that lines pointing forward from the eye could act as "lines of sight" which help the animals to track and capture swiftly moving prey.

"Sighting" normally implies the monocular alignment of two or more external objects so that their images fall in the region of most distinct vision of the observer's retina—that is, the fovea. Quite a different process is involved in the task under consideration, where the animal must estimate the course of a moving object prior to interception. Binocular stereoscopic information from both eyes will be used, together with the various monocular cues to distance (*2*), to estimate the instantaneous position and course of the prey. For this estimate to be as accurate as possible, vision in the binocular field should be reasonably acute, a fine retinal mosaic being combined with a good accommodation mechanism. It is striking that those birds feeding on swiftly moving prey, which constitute the bulk of the evidence cited in (*1*), have visual systems with these properties, rather than necessarily being distinguished by eye stripes. The various hawks and eagles, swallows, many bitterns, and various passerine wing-feeders all possess good overlapping binocular fields and have eyes which each have two fovea (*3*). The central fovea serves for monocular vision in a lateral direction, while a second fovea in the temporal quadrant allows good quality binocular vision in the forward direction, the latter presumably being of prime importance in the pursuit and interception of prey. The accommodation mechanism of such species is also very efficient (*4*). The retinal images of any eye stripes, will, because of the limited depth-of-focus of the eye, only appear as broad blurred patches and it is difficult to see how these could enhance feeding efficiency.

The suggestion made by Ficken *et al.* (*1*) that the light-colored circles around the eyes of some species act as light-gathering devices is also difficult to support. The vertebrate eye is an image-forming device which relies essentially upon the ability of the cornea and lens to bring light from an object to a sharp focus on the retina. Any light scattered or reflected into the eye from a surrounding eye circle would thus simply serve to reduce the contrast of the retinal image and hence diminish rather than enhance its quality. On this basis, as is pointed out by Ficken *et al.*, dark areas in the neighborhood of the eye may indeed serve to reduce unwanted scattering or reflection of light into the eye; however, there is little statistical evidence to support the suggestion that such dark eye patches are significantly more common in those species living in bright habitats than in those living elsewhere.

To summarize, with regard to the optics of the eye and other factors, it appears unlikely that visual efficiency can be significantly enhanced by the eye markings present in some species of birds; the same conclusions apply in the case of other vertebrates. It is much more probable that eye markings are mainly important for the recognition of species, sex, and age, in the same way as the black "moustache" of the yellow-shafted flicker (*Colaptes auratus*) serves to distinguish it from the female (*5*), or as disruptive camouflage.

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