On the Origin of the Sodium *D*-Lines during Twilight

R. PENNDORF
Geophysical Research Directorate, AF Cambridge Research Laboratories, Cambridge, Massachusetts
February 6, 1950

THE experimental evidence concerning the sodium flash during twilight reveals the following facts: (1) The end of the flash is connected with sunset at a certain altitude in the atmosphere. (2) The flash is produced between about 90 and 105 km (emission region), the thickness of which varies from day to day. (3) The flash ends before the emission region enters the earth shadow, corresponding to a shadow region at about 45 km above the earth; this is presumably the ozone shadow. (4) The maximum intensity of the *D*-lines during twilight is about 2×10^9 photons/cm² column and sec. (5) Calculations show the solar radiation producing the flash must be either around 2950 or 2100A, if the shadow is caused by atmospheric ozone.

The existing hypotheses on the origin of the flash are unable to explain these experimental facts. Therefore a chemiluminescent process is proposed, which has been studied in the laboratory by Bawn and Evans.[1] The mechanism is as follows: the primary reaction is

$$Na+N_2O\rightarrow NaO+N_2+1.32\text{ ev}. \quad (1)$$

The secondary reactions are

$$NaO+Na_2\rightarrow Na_2O^*+Na'(^2P)+0.84\text{ ev}, \quad (2)$$
$$Na'(^2P)\rightarrow Na(^2S)+\lambda5890\text{A}. \quad (3)$$

However, in the atmosphere a complete cycle must exist to produce the *D*-lines steadily. Therefore Na_2O, produced by reaction (2), must be dissociated photochemically. The process is

$$Na_2O+h\nu(\lambda\leq2031\text{A})\rightarrow Na_2+O. \quad (4)$$

The existence of N_2O in the upper atmosphere is beyond doubt and the emission region 90–105 km is bound to its vertical distribution, but not to that of sodium.

In order to check this hypothesis, the intensity-time curves measured by Vegard and Kvifte[2] are calculated theoretically, using the oxygen and ozone absorption coefficients for λ2031A and the vertical ozone distribution. It was found, that the intensity-time curves are very sensitive to the vertical distribution of ozone. Thus the ozone content has been obtained between 35 and 70 km and found in accordance with the theory of the origin of atmospheric ozone. Moreover the ozone content agrees with the values found experimentally by the "Umkehr" effect.[3]

A detailed report has been completed and will be published elsewhere.

[1] C. E. H. Bawn and A. G. Evans, Trans. Faraday Soc. **32**, 1570 (1937).
[2] L. Vegard and G. Kvifte, Geofys. Publ. **16**, Nr. 7 (1945).
[3] F. W. P. Goetz, Ergebn. kosm. Phys. **3**, 263 (1938).

Nuclear Magnetic Moments of the Gallium Isotopes

G. J. BÉNÉ, P. M. DENIS, AND R. C. EXTERMANN
Institut de Physique, Université de Genève, Geneva, Switzerland
February 9, 1950

IN their survey of nuclear magnetic moments, H. Taub and P. Kusch[1] noticed a discrepancy between the moments of the isotopes of gallium as determined from spectroscopic data and from magnetic resonance experiments. As was pointed out by Kusch and Foley (unpublished data), this discrepancy is real and is well beyond the limits of the experimental errors.

For the two isotopes, the spectroscopic values[2] $M(Ga^{69})=2.001$ and $M(Ga^{71})=2.543$ are 0.65 percent smaller than the corresponding resonance values[3] $M(Ga^{69})=2.0145$ and $M(Ga^{71})=2.559$.

By applying to the spectroscopic values the Rosenthal-Breit[4] and Kopfermann[5] corrections, assuming a spreading of the charge and magnetic moment over the whole nuclear volume, we are led to a corrective factor which for light nuclei is of the order of $(2ZR_0)/a_0$, where Z is the nuclear charge, $R_0=1.5\cdot10^{-13}A^{\frac{1}{3}}$ is the radius of the nucleus, $a_0=h^2/(4\pi^2me^2)$ is the radius of the first Bohr orbit for the hydrogen atom. We find a correction of 0.72 percent, in good agreement with the experimental discrepancy.

As Crawford and Schawlow[6] pointed out, the magnetic part of the correction, which for light nuclei is of the same order of magnitude as the charge correction, becomes relatively smaller for heavy nuclei.

Hence in our calculation this second correction is slightly overestimated. Thus we see that the spreading of the magnetic moment and of the charge in the nuclei account completely for the discrepancy between the spectroscopic and resonance data.

[1] H. Taub and P. Kusch, Phys. Rev. **75**, 1481 (1949).
[2] G. Becker and P. Kusch, Phys. Rev. **73**, 584 (1948).
[3] R. V. Pound, Phys. Rev. **73**, 1112 (1948).
[4] J. Rosenthal and G. Breit, Phys. Rev. **41**, 459 (1932).
[5] H. Kopfermann, *Kernmomente* (Leipzig, 1940), p. 17.
[6] M. Crawford and A. Schawlow, Phys. Rev. **76**, 1310 (1949).

Beta-Gamma Angular Correlation

THEODORE B. NOVEY
Argonne National Laboratory, Chicago, Illinois
February 20, 1950

MEASUREMENTS on angular correlation in beta-gamma-ray cascades have been made using anthracene scintillation counters in connection with liquid nitrogen cooled 1P21 photomultiplier tubes. The gamma-sensitive crystal consists of a fairly clear cylindrical piece of anthracene $\frac{7}{8}$ in. thick and 1 in. in diameter. A layer of crystals about 30 mg/cm² thick and 0.9 in. in diameter, formed by rapid cooling of a boiling saturated benzene solution of anthracene, provided a counter with a 100 percent counting efficiency for beta-particles.

The sources were mounted on rubber hydrochloride films (*ca.* 0.6 mg/cm²) and were located in the center of a plastic vacuum chamber 6 in. in diameter. This minimizes back and air scattering of the beta-particles and wall scattering of the gamma-rays. A mica window (3 mg/cm²) was located at the beta-crystal counter position. The crystal counters subtended a solid angle of about 0.04 steradian at the source. Measurements were taken at 0° and 90°.

A coincidence circuit utilizing blocking-oscillator pulse shaping and pentode mixing was used with a resolving time of 0.08 microsecond.

Tm^{170} was chosen for investigation because of its high *ft* value (6.3×10^8).[1] Preliminary measurements indicated a high correlation with a value of $\epsilon=0.4\pm0.1$ assuming the correlation function $(1+\epsilon\cos^2\theta)$.[2] Coincidence studies were made on the nuclide to ascertain which radiations showed the correlation. Results were found in general agreement with those of Fraser.[3] They indicated a branching of about 20 percent with about 90 percent conversion of the resulting 84 kev gamma-ray. The *K* x-rays of Yb^{170} were found to contribute to the gamma-counting rate to the extent of 43 percent at zero gamma-absorber. The existence of only a few percent of gamma-radiation per decay accounted for the low coincidence rates obtainable (*ca.* 1 count/min.) when the true and chance coincidence rates became comparable.

The angular correlation measurements were repeated with and without a 1 g/cm² Cu absorber over the gamma-counter. This absorbs 95 percent of the x-rays but only 40 percent of the gamma-rays. Beta-absorption was sufficient to prevent counting of conversion electrons. In order to obtain a higher coincidence rate the vacuum chamber was removed and the counters moved to posi-