Comments and Addenda

The Comments and Addenda section is for short communications which are not of such urgency as to justify publication in Physical Review Letters and are not appropriate for regular Articles. It includes only the following types of communications: (1) comments on papers previously published in The Physical Review or Physical Review Letters; (2) addenda to papers previously published in The Physical Review or Physical Review Letters, in which the additional information can be presented without the need for writing a complete article. Manuscripts intended for this section may be accompanied by a brief abstract for information-retrieval purposes. Accepted manuscripts will follow the same publication schedule as articles in this journal, and galleys will be sent to authors.

PHYSICAL REVIEW VOLUME 180, NUMBER 1 5 APRIL 1969

Hyperfine Effects on the Polarization of Lyman-α Quench Radiation*

J. Casalese and E. Gerjuoy

Department of Physics, University of Pittsburgh, Pittsburgh, Pennsylvania 15213

(Received 31 October 1968)

The polarization fraction of radiation from atomic hydrogen prepared in the metastable $2S$ state and quenched in a small static electric field is calculated in first-order perturbation theory. The calculation includes the electron spin-orbit coupling and the electron-proton spin-coupling interactions. Including the hyperfine effects brings the predicted polarization closer to the observed, but the theoretical results still are slightly outside the experimental error limits.

The polarization of radiation from H ($2S$) atoms quenched in a small (~10 V/cm) electric field has been measured recently by Fite, Kauppila, and Ott.[1] They found a polarization fraction $P = -0.30 \pm 0.02$, where the polarization fraction is defined to be

$$P = (I_\pi - I_\sigma)/(I_\pi + I_\sigma);$$

I_π and I_σ are the intensities of the radiation observed at 90° to the electric field with polarizations parallel and perpendicular to the direction of the quench field. Fite, Kauppila, and Ott calculated the theoretically expected polarization fraction including electron spin-orbit coupling terms only; their prediction, which we have checked is -32.89%, a result slightly outside their estimated limits of experimental error. We would expect the polarization of quench radiation to be accurately predictable by theory. In an attempt to remove the discrepancy between measured and theoretical results we have recomputed the predicted polarization, taking into account the hyperfine interaction. The calculation was done using first-order[2] perturbation theory. The resultant polarization is -32.33%. Thus the hyperfine interactions have a nonnegligible effect on the polarization, and indeed bring the predictions closer to the experimental results. However, the predicted polarization still is outside the experimental error limits quoted by Fite, Kauppila, and Ott.[1]

Although the P-state hyperfine separations have not been accurately measured, their effects on the final result are small. This assertion was checked by permitting the P-state splittings to vary independently over a range encompassing $\pm 20\%$ of their theoretical values. The resultant predicted polarizations varied only between the limits of -32.29 and -32.36%.

If the present discrepancy between the experiment and the theory is confirmed, the most likely cause of the discrepancy is our neglect of the finite widths of the P states. The natural width of the $2P_{1/2}$ state is approximately 100 MHz. This is as large as 10% of the Lamb splitting (1058 MHz) between the $2P_{1/2}$ and the $2S_{1/2}$ states, and is comparable with the hyperfine splitting in the $2S$ or $2P$ states. We have not attempted a careful treatment including linewidth effects, which probably would require computing the $2S$-$2P$ mixing produced by the external static electric field in a quantum electrodynamic framework. It would be interesting if quantum electrodynamics really were needed to account for as large as a 2% deviation in what is a very gross experimental observation, namely, the polarization (equivalently, the angular distribution) of radiation. A less sophisticated procedure, which we also have not attempted, would be to develop a generalization of ordinary perturbation theory applicable to decaying states.

We have profited from several useful discussions of the experiment with Professor Wade Fite. We wish to thank Dr. Norman Bardsley for checking our calculations.

*Work supported by the Advanced Research Projects Agency, Contract No. DA-31-124-ARO-D-440.

[1]W. L. Fite, W. E. Kauppila, and W. R. Ott, Phys. Rev. Letters 20, 409 (1968).

[2]The perturbation can be restricted to the $2S$-$2P$ level system only; all other states are far too distant to be significant. With these restrictions, the next nonzero term in the perturbation expansion is the third-order term; the second-order term vanishes identically owing to parity selection rules, i.e., the Stark potential anti-commutes with the parity operator.

Announcement: Increased Page Charges for the Physical Review

Sharply rising costs have made it necessary for the Council of the American Physical Society to raise the publication charge for papers published in *The Physical Review* from $60 to $75 per printed page. (This is the first such increase since January 1964.) The increased charge will take effect with the issue in June 1969.

As before, an additional charge of $10 will be requested for publication of the Abstract in *Physical Review Letters* and *Physics Abstracts*.

The publication charge for *Physical Review Letters* will remain at $60 per printed page, plus $10 per Letter for supporting abstracting and indexing services.