# Comments and Addenda

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## Multiphoton Ionization of Atomic Hydrogen

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This is a comment on a recent publication by Gontier and Trahin. A comparison of our previously unpublished calculation with their result for the two-photon ionization of atomic hydrogen in the ground state shows significant numerical discrepancies.

In this note, we wish to comment on the recent interesting paper of Gontier and Trahin.[1] The substance of our comment is that there is apparently some question about the accuracy of their numerical results.

Some time ago we showed how the perturbation theoretic result for two-photon ionization could be evaluated exactly for a hydrogenic atom in any initial state.[2,3] The method avoids the necessity for explicitly summing over an infinite set of intermediate states and requires instead the solution of a certain inhomogeneous first-order differential equation. Gontier and Trahin have shown how this method may be generalized to $n$-photon ionization. They derive a hierarchy of inhomogeneous equations; the solution to the first (which also gives the two-photon result) is used to construct the inhomogeneous part of the second (which gives the three-photon result) and so on. They present numerical results for the ground state and perturbation orders 2–8.

As part of our previous work we also calculated the two-photon ionization of the ground state; the result was not included in our publications since our interest was in effects that might be observable with laser beams. However, we feel that it is of interest to present the result now (Fig. 1), for comparison with Gontier and Trahin's Fig. 1.

A detailed comparison of the two curves shows significant discrepancies. For instance, our cross section at around 1400 Å is about twice

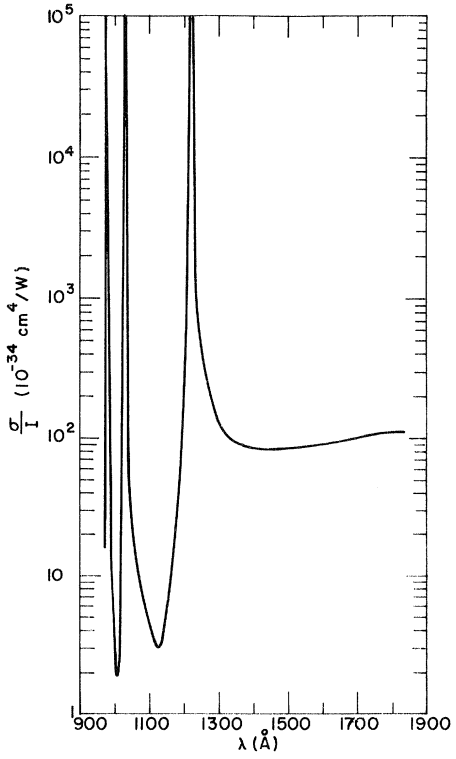


FIG. 1. Two-photon cross section for the ground state of atomic hydrogen.

theirs, and our minimum cross section near 1100 Å is about half theirs and occurs at a longer wavelength.

This discrepancy gives rise to the usual delicate question. We feel that we can have some confidence in our results since our calculations for the 2s state were done twice, with completely different computer programs, and agreed exactly. Nevertheless, it is not our purpose here to insist that our result must be the right one but merely to point out that a disagreement over the exact numerical results exists so that, if and when precise experimental data become available, the calculations should be done over, preferably by a third party.

Finally, we remark that if there is an error in Gontier and Trahin's result for the two-photon case, then it seems likely that the error would become larger as one goes to higher orders in perturbation theory.

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[1]Y. Gontier and M. Trahin, Phys. Rev. 172, 83 (1968). The analytical portion of this paper has also been published in Compt. Rend. 264, 499 (1967).

[2]W. Zernik, Phys. Rev. 135, A51 (1964).

[3]W. Zernik and R. W. Klopfenstein, J. Math. Phys. 6, 262 (1965). This might be an appropriate place to point out that in Eq. (3) of this paper an interference term for the transitions $l \to l-1 \to l$ and $l \to l+1 \to l$ has been omitted. This affects the numerical results for initial states with $l > 0$.

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# Superfluid Fraction of Liquid Helium Contained in Porous Vycor Glass*

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Using fourth sound, there have been recent determinations of the superfluid fraction in helium contained in pores small enough that size effects modify the superfluid state. The results reported for porous Vycor glass,[1] which is presumed to have a random cylindrical capillary system, are sufficiently different, in several respects, from those reported for packed granular powders[2] that the question arises whether there is an inherent difference in the effect of the two kinds of porous geometries. The purpose of this note is to report the results of some measurements on Vycor (Corning porous glass 7930) which do not show these differences.

The superfluid fraction was obtained in a manner entirely similar to that of Refs. 1 and 2 from the measurement of the second and fourth harmonic resonant frequencies of a fourth-sound plane-wave resonator. A more complete description of technique and measurement is given by Guyon and Rudnick.[3] In the present instance the resonator was packed with disks of Vycor glass 2.51 mm thick, 13.13 mm in diameter, separated by layers of lens paper 0.05 mm thick. The total length of the resonator was 12.70 mm. The Q's of the resonant modes varied from about 400 at the lowest temperature to less than 100 at the higher temperatures. Because of the uncertainty in the magnitude of the scattering correction, the measurements are normalized to give the bulk value of $\rho_S/\rho = 0.98$ at 1.2°K. The ratios between the normalized velocity $u_4$ and the unnormalized velocities at 1.2°K were 2.15 and 2.23 for the second and fourth harmonics, respectively. The results are shown in Fig. 1 compared with the bulk values for He II. Also shown for comparison purposes are results obtained with a packed carbon black, Carbolac I, (curve F of Ref. 2) whose grains are approximately 80–100 Å in diameter. The crosses are the results for Vycor reported by Brewer *et al.*[1] It is clear the present results fall into the pattern found for the packed powders and differ markedly from those reported previously for Vycor.

A noticeable difference between the Vycor data here reported and the packed powder data is the reduced values of $\rho_S/\rho$ for the former at the high-temperature end. This may well be a result of imperfectly filling the volume of the resonator with Vycor – a similar effect has been observed with a resonator packed with powder when one end was left unfilled to a length of a few tenths of one percent of its total length. The Vycor of Ref. 1 came from a batch, a sample of which had an average pore diameter of 62.4 Å, and there is evidence that its superfluid onset temperature is close to 2.05°K. We have no independent pore diameter determination for our sample[4] and estimate the temperature onset of superflow to be be-