A New Molecular Beam Resonance Method*

NORMAN F. RAMSEY
Harvard University, Cambridge, Massachusetts
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IN past molecular beam resonance experiments,[1-3] the oscillating magnetic or electric field has been extended approximately uniformly throughout the region in which the molecular states were investigated. It is the purpose of this letter to point out that resonance curves of a different and often more useful character can be obtained by suitably varying the amplitude and phase of the oscillating field along the path of the beam.

A particular case that has been investigated in detail theoretically is that in which the oscillating field is applied in two limited regions at the entrance and exit from the space in which the states are investigated. In this case the formula for the transition probability induced by the oscillating field has been derived exactly and has been numerically averaged over the velocity distribution of the molecules in the beam. For the case of a magnetic moment of spin $\frac{1}{2}$, the mean transition probability induced by an oscillating magnetic field, of such a strength as to make the transition probability at exact resonance a maximum, is shown in Fig. 1 in the immediate neighborhood of resonance. The curve[4] corresponding to past methods with an oscillating field strength to produce the same transition probability at resonance is also shown for comparison purposes on the same figure. It can be seen that the new technique produces a curve whose width is 0.6 that of the corresponding standard method. By reducing the value of the oscillating field below that to give maximum transition probability at resonance, the sharpness of the curve can be further increased both with this technique as shown in Fig. 1 and with the standard technique.[5] If a complete curve were taken so that the effect of the finite length of the oscillating field regions affected the result, the curve should be similar to that of Fig. 2.

There are several advantages to the use of separated oscillating fields: (1) The resonance curves are theoretically sharper making possible higher precision measurements with the same length of oscillating field. (2) The resonances are not broadened by irregularities in the homogeneous constant fields since the space average value of the field over the path of the molecule determines the resonance position. This advantage is of great practical importance and in many cases should increase the measurement precision by factors of ten or more. Since the averaging is only along the path of the molecule, considerable uniformity must still be preserved over the beam height. (3) This technique is more easily adapted to very short wave-length radiation where the wave-length of the radiation is less than the length of the homogeneous field region. (4) The technique is adaptable to experiments where the oscillating field cannot be made to penetrate the region where the measurement is desired, as in an experiment now being started on the Larmor precession frequency of neutrons in iron. (5) By

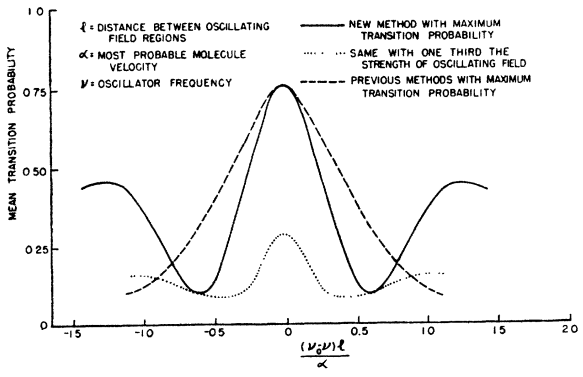

FIG. 1. Transition probability in immediate vicinity of resonance.

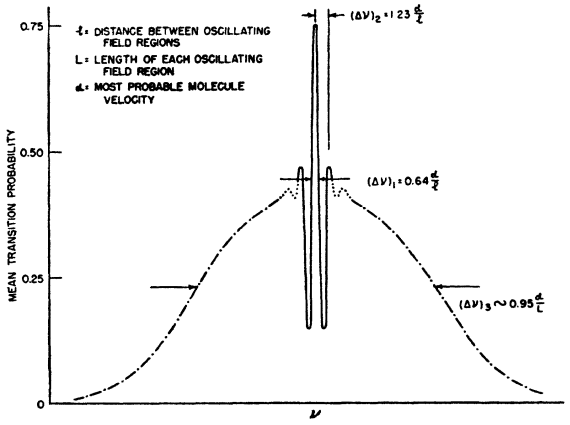

FIG. 2. Transition probability showing effect of finite length of oscillating field regions.

introducing a 90° relative phase shift between the two oscillatory fields the resonance curve can be altered to a dispersion type curve which is particularly suited for a precision measure of the position of exact resonance.

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A Suggestion Regarding Emission Phenomena in (Ba−Sr)O Cathodes

E. S. RITTNER, F. K. DU PRÉ, AND R. A. HUTNER
Philips Laboratories, Inc., Irvington-on-Hudson, New York
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THE model generally used to explain thermionic emission, i, and electrical conductivity, σ, of (Ba−Sr)O cathodes consists of a donor level widely separated from the conduction band ($\Delta\epsilon\sim 1.4$ ev).[1,2] This model leads to the following formulas:

$$i=[n_b^{\frac{1}{2}}(8\pi m)^{\frac{1}{2}}e(kT)^{5/4}/h^3](1-r)\exp[-(\chi+\tfrac{1}{2}\Delta\epsilon)/kT], \quad (1)^3$$

$$\sigma=\sigma_0\exp(-\Delta\epsilon/2kT), \quad (2)$$

where n_b is the density of donors and χ the electron affinity. The temperature dependence of i and σ for a well-activated cathode is thus satisfactorily accounted for using the above $\Delta\epsilon$ and $\chi\sim 0.3$ ev, corresponding to a work function of ~ 1 ev. However, there remains the difficulty that, taking n_b as $3\times 10^{17}/\text{cm}^3$, the chemically determined value;[4] the work function as 1.01 ev, based on recent data by Wright;[5] and assuming the reflection coefficient, r, to be zero, the calculated value of i at 740°C is 51 amp/cm² as compared to experimental d.c. values[5] of the order of 0.5 amp/cm².

Many attempts have been made to explain this difficulty. We think, however, that the situation has been completely changed by the recent work of Vink,[6] who has extensively investigated the conductivity of (Ba−Sr)O cathodes over a much wider temperature range than that employed previously. This work reveals a region of lower activation energy in temperature range *I* (600–800°K) than that in range *II* (800−1000°K).[7] The value of the slope in range *I* decreases with activation and in an active cathode can be as low as 0.1–0.2 ev. Vink has concluded that there are two parallel conduction mechanisms in the cathode. One is the electron conduction through adjoining particles of the coating, which dominates below 800°K. The other is the conduction by the electron gas in the pores between the particles, which dominates above 800°K. The latter conclusion is supported by his calculations of the coating resistance based upon the electron gas