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Abstract

Full Text

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ON THE POSSIBILITY OF DETECTING HIGH-FREQUENCY RADIATION AT LOWER FREQUENCIES

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The behavior of certain quantum systems (for example, paramagnetic ions in crystals) in magnetic fields opens up broad possibilities for radio-engineering applications, and, as the successful development of quantum radiophysics shows, these possibilities are far from exhausted. It seems of interest to discuss one of them, which apparently has not yet been noted by anyone.

Let us consider some quantum system, the degeneracy of whose states is completely or partially removed by a static magnetic field H_0 acting on it. Suppose, in addition, that two alternating magnetic fields act on the system: $H_1 \cos \Omega t$, parallel to H_0, and $H_2 \cos \omega t$, perpendicular to H_0, with $\Omega \ll \omega = g\beta H_0 \hbar^{-1}$. Then, as the analysis shows, transitions with absorption or emission of energy should occur which satisfy the condition [(1)]

$$\mathcal{E}_1 - \mathcal{E}_2 = \hbar(n\omega \pm k\Omega),$$

where $\mathcal{E}_1$ and $\mathcal{E}_2$ are the energies of the Zeeman sublevels, and n and k are arbitrary integers.

The probability of such transitions depends strongly on the values of these numbers and will be maximal for $n = k = 1$. Therefore, if the trivial case $n = 1,\ k = 0$ is excluded, the transition of greatest interest is

$$\mathcal{E}_1 - \mathcal{E}_2 = \hbar(\omega \pm \Omega).$$

The described property of quantum systems opens up the possibility of detecting radiation of high frequency ω at a considerably lower frequency Ω. The maximum possible ratio of these frequencies depends on the linewidth of the observed transition and, as our experiments have shown, may reach values of the order of 10^5.

The method of measurement (detection) of high-frequency quanta under discussion apparently makes it possible to extend the well-developed methods for detecting radio-frequency and microwave radiation to those regions of the spectrum where either reliable radiation detectors are absent or they have unsatisfactory characteristics (poor sensitivity, a large value of the time constant, complexity of construction).

In the case of using a two-level system for detecting high-frequency oscillations, it may be necessary to use very large magnetic fields; this difficulty can be overcome either by using pulsed magnetic fields or by using multilevel quantum systems having a substantial initial splitting between the working levels.

It seems possible to create a device whose time constant (the time constant will be determined by the relaxation properties of the quantum system) will have a value of the order of 10^{-7}–10^{-4} sec.

An analogous effect should also occur when electric fields are used (if the particles possess electric moments).

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CITED LITERATURE

1. P. Jung, *Physika*, **27**, 707 (1961).

Note: Figure translations are in progress. See original paper for figures.