Letters to the Editor

A PARAMAGNETIC AMPLIFIER AND GENERATOR, USING Fe^{3+} IONS IN CORUNDUM

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IN published reports on the construction of quantum-mechanical amplifiers and generators, Gd^{3+} (reference 1) and Cr^{3+} (references 2-8) have been used as the paramagnetic ions. There is also a report of an attempt, as yet unsuccessful, to utilize the ion Ni^{2+} (reference 2) for this purpose.

We have carried out a study of the possibility of constructing a paramagnetic amplifier and generator using the ion Fe^{3+} in corundum. The spectrum of the electronic paramagnetic resonance of the ions Fe^{3+} in the lattice Al_2O_3 has been studied earlier by the authors.[9] The Fe^{3+} ion is in an S state, and has electronic spin $S = 5/2$. In corundum the Fe^{3+} ions form two nonequivalent systems, differing from one another in the direction of the cubic axes of the crystalline electric field. The axes of trigonal symmetry of both systems are parallel. If the trigonal axis of the crystalline electric field is parallel or perpendicular to an externally applied constant magnetic field, then the energy levels of both systems coincide for any magnitude of the magnetic field and arbitrary orientation of the cubic axes. If, however, the trigonal axis of the crystal makes an angle with the direction of the external magnetic field, then the energy levels of both systems coincide only for some definite orientations of the cubic axes of the non-equivalent systems of ions; these orientations can be found by turning the crystal around the trigonal axis until the spectra of the electronic paramagnetic resonances of both systems coincide. In the absence of an external magnetic field the six spin levels of each system are split by the electric field of the crystal into three doublets, the distances between which are 0.39 and 0.62 cm^{-1}. From a comparison of the relative intensities of the spectral lines at 290 and 4.2°K., it was established that the lowest spin doublet is the one which in strong magnetic fields is split into levels characterized by magnetic quantum numbers $M = \pm 1/2$, i.e., the constant, D, in the spin Hamiltonian is positive. For the paramagnetic amplifier levels were used which, if the influence of the cubic components of the crystalline field is neglected, are characterized in the parallel orientation by the quantum numbers $M = -5/2,\ -3/2,\ -1/2$. The presence in the crystalline field of a cubic component mixes the states, even in the parallel orientation, as a result of which transitions are allowed between any of the chosen levels. For amplification the levels with $M = -3/2$ and $-1/2$ are used, and the auxiliary radiation induces transitions between the levels with $M = -5/2,\ -1/2$. The trigonal axis of the crystal made a small angle with the direction of the constant magnetic field. The cubic axes were oriented so that the energy levels of both non-equivalent systems of ions coincided.

Amplification and generation were observed at a temperature of 1.8°K. for a wave-length ~3.2 cm. with auxiliary radiation of wave-length ~1.2 cm. The magnitude of the constant magnetic field was ~1200 Oe.

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164