B10. Spontaneous Emission Probabilities at Radio Frequencies. E. M. Purcell, Harvard University.—For nuclear magnetic moment transitions at radio frequencies the probability of spontaneous emission, computed from

\[ A_\nu = \frac{(8\pi \nu^2/c^3)\hbar \nu (8\pi^2\mu^2/3\hbar^2)}{\text{sec.}^{-1}}, \]

is so small that this process is not effective in bringing a spin system into thermal equilibrium with its surroundings. At 300°K, for \( \nu = 10^7 \) sec.\(^{-1} \), \( \mu = 1 \) nuclear magneton, the corresponding relaxation time would be \( 5 \times 10^{21} \) seconds! However, for a system coupled to a resonant electrical circuit, the factor \( 8\pi \nu^2/c^3 \) no longer gives correctly the number of radiation oscillators per unit volume, in unit frequency range, there being now one oscillator in the frequency range \( \nu/Q \) associated with the circuit. The spontaneous emission probability is thereby increased, and the relaxation time reduced, by a factor \( f = 3Q\lambda^3/4\pi^2V \), where \( V \) is the volume of the resonator. If \( a \) is a dimension characteristic of the circuit so that \( V \sim a^3 \), and if \( \delta \) is the skin-depth at frequency \( \nu \), \( f \sim \lambda^3/a^2\delta \). For a non-resonant circuit \( f \sim \lambda^3/a^3 \), and for \( a < \delta \) it can be shown that \( f \sim \lambda^3/a\delta^2 \). If small metallic particles, of diameter 10\(^{-3} \) cm are mixed with a nuclear-magnetic medium at room temperature, spontaneous emission should establish thermal equilibrium in a time of the order of minutes, for \( \nu = 10^7 \) sec.\(^{-1} \).