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Citation Classics

Bloembergen N, Purcell E M & Pound R V. Relaxation effects in nuclear magnetic resonance absorption. *Physical Review* **73**:679-712, 1948.

The exchange of energy between a system of nuclear spins immersed in a strong magnetic field, and the heat reservoir consisting of the other degrees of freedom (the lattice) of the substance containing the magnetic nuclei, serves to bring the spin system into equilibrium at a finite temperature. In this condition the system can absorb energy from an applied radiofrequency field. With the absorption of energy, however, the spin temperature tends to rise and the rate of absorption to decrease. Through this saturation effect, the spin-lattice relaxation time can be measured. [The *SCI*® indicates that this paper was cited 1,145 times in the period 1961-1975.]

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"When I arrived early in 1946 from the wartorn Netherlands as a graduate student at Harvard University with the objective of doing some kind of research leading to a Ph.D. thesis in physics, it was less than two months after E.M. Purcell, R.V. Pound and H.C. Torrey had demonstrated nuclear magnetic resonance in condensed matter experimentally. This work was stimulated by discussions of a group of physicists active in World War II radar development at the M.I.T. Radiation Laboratory. F. Bloch and W.W. Hansen, who were involved with radar work in other groups, independently and nearly simultaneously carried out a similar experiment, which they, together with M.C. Packard, called nuclear induction....

"It was my good fortune to arrive at the right time at the right place. Purcell, who had just been appointed as an associate professor of physics at Harvard, needed somebody to assist him in exploiting the discovery. Since Purcell and Pound were preoccupied with writing volumes for the monumental M.I.T. Radiation Laboratory series during the spring of 1946, I had time and opportunity. as Purcell's first graduate student, to become familiar with novel experimental techniques and catch up with my senior mentors in the field of magnetic resonance. After years of isolation in the Netherlands occupied by German forces who had closed the Dutch universities, it was a most stimulating experience to learn and discuss modern physics. The field of nuclear magnetic resonance proved to be enormously fertile, with numerous ramifications in atomic, molecular and solid state physics. Within 18 months I had plenty of material for a Ph.D. thesis, which I submitted at Leiden University in 1948, because I had already previously passed all required formal examinations in Holland. The same material proved the basis for the paper which appeared in *Physical Review* and is so often quoted as BPP.

"In retrospect, it remains a very basic and seminal paper. It deals with the relaxation times, T_1 and T_2, introduced by Bloch and Frenkel, in solids, liquids and gases. The sharp resonances which are based on the concept of motional narrowing are basic to NMR spectroscopy. The exploitation of this field by the chemists and biochemists, who are more numerous in numbers and more prolific in authoring papers than physicists, is undoubtedly responsible for the high incidence of citation. This does not fully explain, however, why the paper is still so much quoted in the period 1961-1975. 13 to 28 years after its original publication. Many comprehensive books on the subject of magnetic resonance and relaxation now exist, which certainly constitute an improvement on the naive early experimental and theoretical discussions of BPP. Perhaps new workers, confronted with the complexities of modern NMR and its applications, like the account of our early wrestling with some basic problems....

"All three co-authors are still at Harvard University, although their research interests have diverged in different directions. EM. Purcell is University Professor, and his research is focused on radioastronomy and astrophysics. R.V. Pound is Mallinckrodt Professor of Physics and has done fundamental work on Mossbauer spectroscopy, although he keeps an active program on nuclear magnetic relaxation in solid hydrogen. N. Bloembergen is Rumford Professor of Physics in the Division of Engineering and Applied Physics, and his present research is concerned with nonlinear optics."