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Nobel Prize in Physics 1952

Felix Bloch

Edward Mills Purcell

The Nobel Prize in Physics 1952 was awarded jointly to Felix Bloch and Edward Mills Purcell *"for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith"*

RESEARCH INFORMATION:

For the man in the street I suppose the compass needle is the most familiar magnetic instrument. But when and where the compass was first used is a much-debated question, where we grope between Chinese records from the year 2,600 B.C. and ship's logs made by the Norsemen in their Icelandic voyages in the 12th and 13th centuries. It is typical of all such records, whether of gunpowder or the compass, that they refer to inventions that had long been in use. The very idea of invention, of having been the first, had doubtless not the same significance formerly that it has today. As a matter of fact, the scientific study of magnetism in the sense in which we understand it, was begun only with the publication in London of Gilbert's work De Magnete in the year 1,600 A.D. The subsequent investigation and classification of magnetic substances led to their division into three categories: the ferromagnetics or strong magnetics such as iron, cobalt and nickel; the paramagnetic or weak magnetics, including chiefly crystals and fluids; and finally the diamagnetics, with their magnetic repulsion, a property intrinsic in all substances. A compass needle made of a diamagnetic substance turns at right angles to the magnetic lines of force, and thus comes to point in an east-westerly direction. Fortunately, diamagnetism is too weak to cause shipwreck in this way. This wealth of magnetic is today joined by a fourth category, the nuclear magnetism deriving from the atomic nucleus.

The magnetic field radiating from the infinitesimally tiny atomic nucleus is so feeble that its existence was still scarcely more than divined only fifteen or twenty years ago. Thus when Bloch and Purcell, this year's Nobel Prize winners in Physics, are able to register nuclear magnetism with a precision exceeding almost all other measurements in physics, one supposes that this must be thanks to the use of special methods and accessories. But what interest or useful purpose may conceivably be served by such subtleties?

If we consider the methods that have been employed, we soon recognize the idea that runs through all more advanced measurements of a body's magnetic moments. Thus the celebrated German mathematician and physicist, Karl Friedrich Gauss, determined in 1836 the magnetic moment of thc compass needle in relation to its moment of inertia, simply by observing the oscillations of the needle in a magnetic field of known strength.

Now the electrons or the atomic nucleus do not, it is true, behave in quite the same way as the compass needle in the magnetic field, but rather in the manner of the top, the gyroscope, which spins and precesses about the perpendicular. But the electronic and nuclear spins are just as characteristic for these particles as are their electric charge and mass (the atomic weights), so that the deep import of a determination of their gyromagnetic indices becomes immediately obvious.

Now what possibilities exist for the observation and measurement of the frequencies of the electrons and the atomic nucleus in the magnetic field? This is where the new phase in the development comes in. In this connection I need only remind you of the resonance between our radio apparatuses and radio waves. The comparison is actually quite justified, as the electronic and atomic nuclear frequencies in the magnetic field fall

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precisely within the region for the short-wave radio with wavelengths varying between some tens of meters and the centimeterwaves employed in radar technique.

These atomic frequencies in the magnetic field are so characteristic for each element and its isotopes that they are more undisturbed and regular than the balance-wheel, pendulum and vibrating quartz-crystal in our modern chronometers.

The method for the determination of the nuclear magnetic moment through resonance with radio waves has long been well-known, and was rewarded by the Academy of Sciences with the Nobel Prize for the year 1944 to Rabi. It was with similar methods that the paramagnetism of crystals deriving from the electronic spin was investigated by Gorter in Leiden.

Rabi carried out his investigations on nuclear magnetic moments according to the molecular-ray method, an artificial method which has, certainly, the inestimable advantage that the investigated substance is in a state of very high rarefaction, though at the same time this limits its application. The methods of Purcell and Bloch imply a great simplification and generalization in this respect, which enables their application to solid, liquid and gaseous substances. This brings us to the useful purposes which may be served. Since each kind of atom and its isotopes have a sharply defined and characteristic nuclear frequency, we can in any object placed between the poles of an electromagnet seek out and examine with radio waves all the various kinds of atom and isotopes present in the object in question, and, *which is the essential point*, this without in any perceptible way affecting the same, its form, crystalline structure, etc. This form of analysis *in situ* is therefore probably not parallelled in any other known methods of analysis. Its extraordinary sensitiveness also makes it particularly well-adapted as a micro-method in many scientific and technical fields

Professor Purcell. As far I have been able to follow your activities since you stopped working at the great Radiation Laboratory at M.I.T. at the end of the War, and up to your development of the excellent method of *nuclear resonance absorption* for which you have been awarded your Nobel Prize, you have happily realized man's old dream of beating the sword into a ploughshare. Your wide experience in electronics and the deep interest you early showed in paramagnetic phenomena may thus conceivably have contributed to the invention of your method, which through its extraordinary sensitiveness gives us a deep insight into the constitution of crystals and fluids, and the interactions, so-called relaxations, between the tiniest particles of matter.

In part with this method, and in part without it, you and your collaborators have made a number of important discoveries, among which I would like particulary to stress the three following:

Your method for studying nuclear magnetic resonance in weak magnetic field produced according to the solenoid method, which is of great value for the absolute determination of nuclear magnetic moments.

In the very interesting experiment which you performed together with Dr. Pound, you have produced with paramagnetic resonance the rather unique situation in which the state of the atomic nucleus corresponds to negative temperatures in the absolute-temperature scale

Finally, as a quite spectacular discovery I may mention your observation with Dr. Ewen in 1951 of a line in the galactic radiospectrum caused by atomic hydrogen, an important contribution to radioastronomy.

Please accept our congratulations, and receive your Nobel Prize from the hands of His Majesty.

Professor Bloch. It would be difficult in the few minutes at my disposal to try to give the main features of the nuclear induction method for which you have been awarded your Nobel Prize. It would be still more difficult for me to give an exhaustive account of the ways that led you to this invention.

You began your career as a theoretical physicist, well-known for your fundamental contributions to the theory of metals.

When, quite unexpectedly, you went over to experimental research, this must have been, I feel, with deliberation and assurance. For you had in your kitbag a tool of extraordinary

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value, the method for the magnetic polarization of a beam of neutrons. The inestimable value of possessing a good idea, of indefatigably testing and perfecting it, is best illustrated by your precision-measurements of the magnetic moment of the neutron, one of the most difficult and at the same time most important tasks in nuclear physics.

But ideas give birth to new ideas, and it was, as I understand, in this way that you hit upon the excellent notion of eliminating the difficult absolute determination of the magnetic field by a direct measurement of the neutron moment in units of the proton cycle (the nuclear magneton). According to your own account it was this solution which finally led you to the nuclear induction method.

<u>For more details please visit:</u>

http://www.nobelprize.org/nobel_prizes/physics/laureates/1952/press.html