Think It Over

This section of *Resonance* presents thought-provoking questions, and discusses answers a few months later. Readers are invited to send new questions, solutions to old ones and comments, to 'Think It Over', *Resonance*, Indian Academy of Sciences, Bangalore 560 080. Items illustrating ideas and concepts will generally be chosen.

Answer to *Locate the Electrons*, Think–it–Over, June 1998, p.75.

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Locate the Electrons

In the June 1998 issue of *Resonance*, Anirban Sadhu of Pune posed the '*Locate the Electrons*' question. This was prompted by the usual textbook descriptions of the Bohr theory of the hydrogen atom, which have the electron 'jumping' from an outer orbit of larger radius to an inner orbit of smaller radius.

The question: Surely this is not instantaneous, the emission processes takes some time, and what is the electron doing in this time, in particular is it in a region forbidden by Bohr's postulates? Three readers have responded, pointing out that the question is based on an oversimplified picture. Bohr's theory was the cradle in which our understanding of atoms was born, but one does not stay in the cradle forever! Bohr's orbits have now evolved from sharp circles to 'orbitals' (see cover) which are broad probability distributions calculated by squaring the absolute value of a wave function. Such a pattern represents our imperfect knowledge of the position of the electron even when it has a definite energy. Now this energy can be given out in an electromagnetic form (i.e. the atom can emit a photon). This is accompanied by a change to a lower state which has a different probability distribution. So the question must be restated. If we were able to measure the probability distribution of the electron position, would it correspond to the upper or lower state? As Rahul Siddharthan explains in the Classroom section of this issue, in quantum systems it is sometimes *not* an either-or choice. One can construct a wave function which combines (superposes) the two states in some proportion.

So, if we could make later measurements on a collection of atoms all originally prepared in the upper state, we need to use a wave function in which the atoms (as well as the radiation) are in superposition states. The nature of this superposition changes with time, and can be calculated by quantum mechanics.