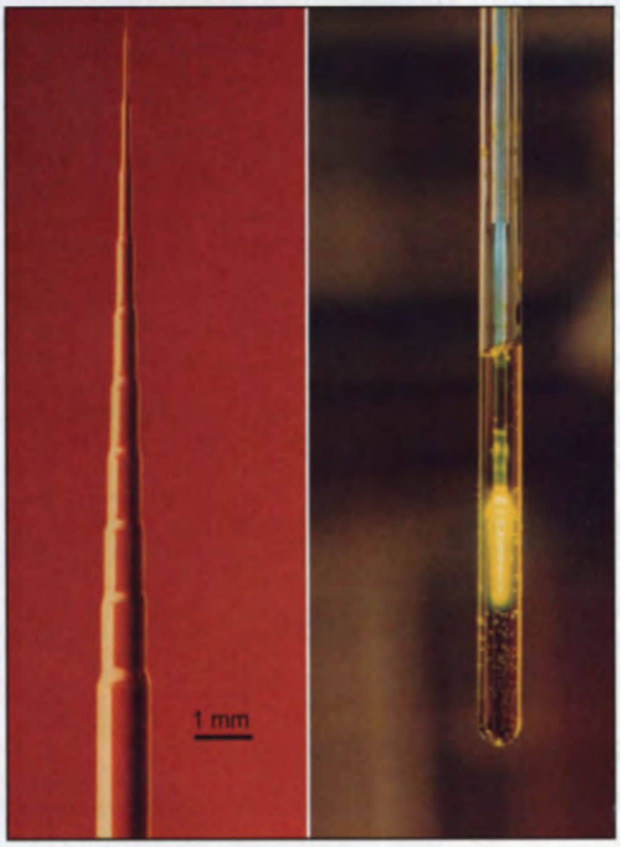
Tapered fiber provides NMR sample illumination

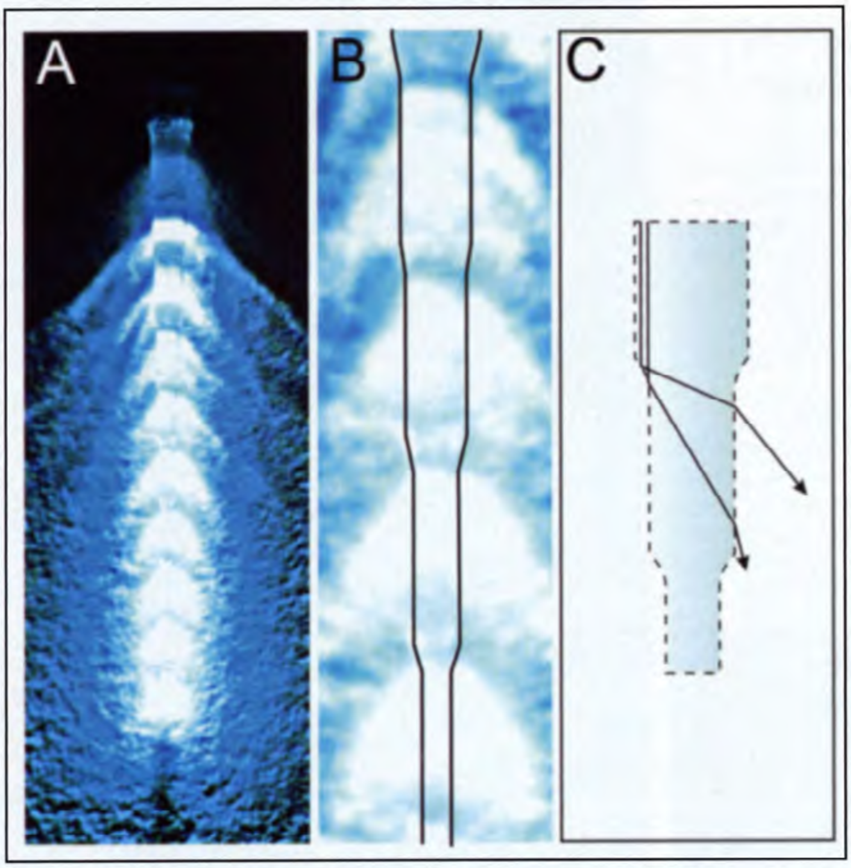
Photochemical nuclear magnetic resonance (NMR) experiments, such as photochemically induced dynamic nuclear polarization, and studies of protein surfaces and photoactive proteins require laser illumination of the sample inside the narrow bore of a superconducting NMR magnet. Efficient delivery of light to the sample, beyond and around the probe coils, capacitors, temperature control system and gradient coils, is difficult and has been a long-standing technical problem.

A research team at the University of Oxford in the UK recently suggested a thin tapered optical fiber as a means of efficient and uniform laser light delivery to the NMR sample.

A variety of sample illumination schemes have been tried, but none has been ideal. In the ideal case, the entire sample volume would receive light uniformly because nonuniform illumination generates concentration and temperature gradients that distort chemical kinetics and that bias the results. A good sample illumination setup also shouldn't require NMR probe



***The tapered fiber on the left can be used for illumination in NMR experiments. On the right is the fiber illuminating a solution. The fiber cone is less than 50 µm, but it looks larger because of the lensing effect of the solution. Images reprinted with permission of the* Journal of Magnetic Resonance.**



The tapered fiber is shown emitting on a white surface (A). A magnified portion of the center of A is shown in B. In C are the likely paths of the light rays.

modification, and should be easy to assemble and move from one spectrometer to another.

The tapered fiber developed by Ilya Kuprov and Peter J. Hore provides light from above the sample and scatters it uniformly along the axis of an NMR tube. To create the illuminating fiber, they used an etching process to step-taper one end of a Newport optical fiber that had a 1-mm-diameter core. They created fiber tips of various lengths that decreased diameters in seven to 15 steps.

To measure the light intensity distribution within the sample, they used a ^{19}F photochemically induced dynamic nuclear polarization effect on 4-fluorophenol sensitized by flavin mononucleotide. The amount of nuclear polarization generated in this system is, in certain conditions, proportional to the local light density, which allowed measuring the light intensity profiles using NMR imaging techniques.

The researchers tested the fiber tips in a Varian Inova 600-MHz 14.1-T NMR spectrometer. A Spectra-Physics argon-ion laser operating in multiline mode at 10 W at predominantly 488 and 514 nm provided light pulses 100 ms long. The light was focused into a 6-m-long fiber via a Newport 5× objective lens. The other end of the fiber was connected to a 2-m-long fiber with a tapered tip that they placed inside a 5-mm NMR tube.

They found that shorter cones (with steeper shoulders) tended to emit light predominately from the shoulders, which produced nonuniform illumination. Very long cones with many steps emitted light only from the tip via total internal reflection. The best results came from cones with 10 to 15 1.0- to 1.5-mm steps. In these fibers, the vertical sections between the shoulders of the steps emitted light at ~45° to the fiber axis. The researchers noted that using steps to create the cone was essential because smooth cones emitted most of their light from the tip.

Their tests revealed that the fiber cone does not significantly deteriorate spectral resolution, and it displaces only about 5 percent of the total sample volume. In addition, it emits light into a volume around 25 mm^2 as compared with the 0.8 mm^2 area that a square-cut fiber can produce and, consequently, produces more homogeneous heating than a cut tip.

The researchers found that the tips were robust if they were free from scratches. If a tip did break from inaccurate insertion into the NMR, it could be repaired using the same etching process that produced it. Since the publication of this paper, they have worked with another group to use the setup to study GFP. □

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Imaging neurons as they two-step

Researchers in Mary E. Hatten's laboratory at the Rockefeller University of New York have shown that, to paraphrase the Chinese proverb, the journey of a thousand neurons begins not with a single step, but with two.

Using a relatively new variant of yellow fluorescent protein and a spinning disk confocal microscope, they revealed that migrating neurons move in a two-step stroke. The centrosome moves first, and the nucleus follows. Each tiny step is about a micron.

In this inchwormlike fashion, neurons migrate along glial fibers to form the cortex, a key part of the development of the young brain. The researchers found that this two-step can be stopped by too much or too little of the signaling protein Par6-alpha.

"Neuronal migration defects underlie a variety of genetic diseases like epilepsy, autism and mental retardation," said David J. Solecki, a research team member and Rockefeller postdoctoral fellow.

Solecki continued, "We believe that