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Tracking Fluid Flow Inside a Porous Material

Tracking fluid flow inside a porous material can now be performed with remote MRI viewing. MRI is an important means for sub-surface viewing of soft objects like biological tissue or moist in solid things like rice grains. In a new approach, scientists at Lawrence Berkeley National Laboratory and UC Berkeley in collaboration with Schlumberger-Doll Research have developed a style of MRI that can be used to see how a gas flows through a porous rock, an experimental tool with possible applications in oil exploration, in situ monitoring of natural and manmade structures, and industrial processes where the flow of a fluid through an opaque material is important.

To accomplish this, Josef Granwehr (joga@waugh.cchem.berkeley.edu) and Yi-Qiao Song (ysong@SLB.com) and their colleagues use not one radio coil but two, separated in space. In MRI it is customary to cause atomic nuclei in a sample (given an orientation by an external magnet) to be disturbed by magnetic waves induced by the coil. The same coil is used a moment later to detect the radio waves given back out by the target nuclei, thus providing information about their whereabouts.

In the Berkeley setup, one coil surrounds the porous sample and can, in combination with magnetic field gradients, selectively disturb nuclei of the fluid in a voxel (a tiny volume element) anywhere in the sample, while a second independent coil, positioned at the exit of the sample, can detect the emerging material. The first coil is therefore used to tag certain nuclei at a given point in time, while the second coil is used to record the time of flight of the affected nuclei as they leave the sample.

Possessing location and velocity of any portion of the gas allows researchers, in effect, to look inside the rock and watch its flowing and unfolding. One can trade off the minimum detectable partial pressure of the target nuclei (tens of millibar up to one bar) for time resolution (tens of microseconds to milliseconds) or vice versa.
(Granwehr *et al.*, Physical Review Letters, upcoming article)

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