Is there really no sound in space?

Maintaining web sites about acoustics guarantees this editor a regular supply of emailed questions. "Space isn't quite empty" wrote one correspondent, "so can it transmit sound?" Obviously not audible sound, I thought, but can we put a lower bound on the wavelength?

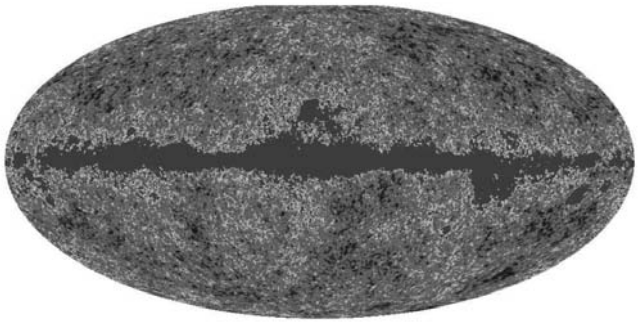
The first problem is having enough atoms or molecules: pressure is a macroscopic concept, and its usual use presumes a scale large compared with the mean free path (m.f.p.) between molecular collisions. In air, the m.f.p. is rather less than a micron, but in space? Just from dimensions, we can write m.f.p. ~ [(scattering cross section)(number density)]$^{-1}$. (There is also a numerical factor, of order one, which depends on the velocity distribution.)

Taking the atomic scattering section as ~ 10^{-20} m^2, and number density as ~ 10^6 molecules.m^{-3}, we get a m.f.p. of about 10^{14} m or 0.01 light years. Collisions are rare. So, to talk of cosmic sound waves, we'd need to consider wavelengths much longer than this. The frequency would be expressed in femtohertz.

But that's now. When the universe was younger, hotter and denser, the mean free path was shorter and the speed of sound higher. Younger than about 400,000 years, the temperature was above 3000 K and the medium was a plasma. Much earlier than that and the universe would have been a very noisy place, although the section on relativistic acoustics seems to be a lacuna in acoustics texts.

As the universe expanded, the scale of the local variations in average density expanded. Some of the variations in density were exaggerated by effects that are usually ignored by acousticians: gravity and star formation. Measuring the remaining ultralong wavelength acoustic waves directly is difficult.

We can, however, infer the acoustics of the young universe. When the universe was a plasma, matter and radiation were strongly coupled, so the cosmic microwave background (CMB) reports the spatial variations in temperature and therefore density of the hot, pre-stellar, pre-galactic universe.



Q band map of the CMB and our galaxy, courtesy of NASA. The grayscale shows ± 0.2 mK

The CMB is of course of interest to astrophysicists and cosmologists. Mark Whittle of the University of Virginia came to our lab to talk about it and Alex Tarnopolsky, then a postdoc in our lab, converted some of his density files, transposing them up 50 octaves (yes, 50) to put them into the audible range. Mark now uses it in his seminars and calls it the "primal scream of the infant universe". Mark has a good, popular account of these density variations, including that sound file, on his web page at www.astro.virginia.edu/~dmw8f/. And our FAQ is at www.phys.unsw.edu.au/jw/musFAQ.html

Joe Wolfe

Acoustical Interludes were an innovation of a previous editor, Neville Fletcher. They appeared when the contents of an issue was a little less than 4n pages, where n is a positive integer.