Off-the-shelf electronics turn up gain on spectroscopy

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Whether the object of attention is a novel aspect of the universe or an enigmatic and distant colleague, listening is key to nearly any effort to seek understanding. And not just with your ears. Spectroscopy, the study of how atoms absorb and emit electromagnetic radiation, is like listening, too. The technique is central to a range of physics experiments and can be thought of as an attempt to filter out useful information from what various sensors and detectors often first "hear" as undifferentiated electromagnetic noise.

Now, a new twist on spectroscopy, described in the American Institute of Physics' in journal Review of Scientific Instruments, allows for an unprecedented level of such filtering -- one that could transform everything from the search for extraterrestrial intelligence to super-sensitive spy gear to scan hotel rooms for hidden microphones or cameras.

The technique was demonstrated on the slice of the electromagnetic spectrum containing frequencies on which terrestrial radio stations broadcast music. Current spectroscopy techniques can take such radio signals and tell you, in effect, the average volume and pitch of each moment of the music. However, if a given moment is made up of several notes played simultaneously -- a chord, say -- that fact is more or less invisible.

Or rather, it was invisible before the recent work of doctoral student Sebastian Starosielec and professor Daniel Hagele, both at Germany's

Ruhr University Bochum. By stitching together a MHz-sampling card –- a radio-frequency version of a sound card -- and a multi-core graphics CPU, the two combed through a broad band of the radio spectrum in extra-fine detail. Their technical achievement, which determined in real time correlations among many thousands of pairs of frequencies, for the first time makes it easy to distinguish between a soloist and an ensemble based only on analysis of spectra.

Beyond the search for E.T. and illicit bugs, the technique could prove useful "for detecting anything that is not pure noise," says Hägele. Other applications could include better measurements of various physical systems, particularly in atomic and solid state physics, and the possibility of better communication signal recovery to be used on and off the planet's surface.

Hägele gives the following example to illustrate the power of the the technology: Imagine a TV show was broadcast daily from Mars, and the signal was received, along with a vast amount of background noise, here on Earth. After a few days "we would be able to reconstruct the show's introduction, including the theme song and images, just from spectroscopic data," he says.

More information: The article, "Two-dimensional higher order noise spectroscopy up to radio frequencies" by Sebastian Starosielec, Rachel Fainblat, Jörg Rudolph, and Daniel Hägele appears in the journal *Review of Scientific Instruments*. See: link.aip.org/link/rsinak/v81/i12/p125101/s1

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