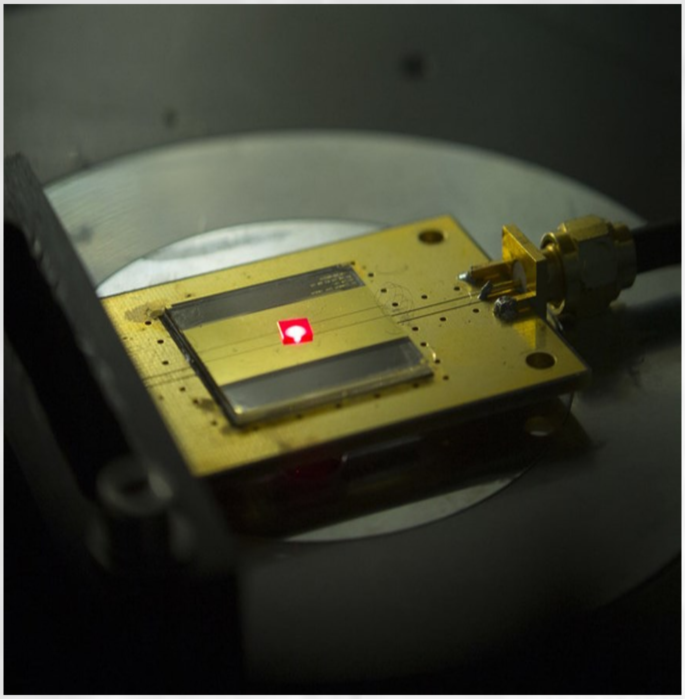
World's smallest radio receiver has building blocks the size of two atoms

Physicists at Harvard have built a radio receiver out of building blocks the size of two atoms. It is, almost certainly, the tiniest radio receiver in the world. And since it's a radio, it can play whatever you want to send its way, including Christmas music, as this video by the Harvard team that designed it makes clear:



A tiny radio receiver built from components the size of two atoms. It emits a signal as red light, which is then converted into an electrical current and can be broadcast as sound by a speaker or headphone.

Electrical engineering professor Marko Loncar and graduate student Linbo Shao applied basic radio engineering principles to a very small-scale machine. This tiny radio — whose building blocks are the size of two atoms — can withstand extremely harsh environments and is biocompatible, meaning it could work anywhere from a probe on Venus to a pacemaker in a human heart.

The radio uses tiny imperfections in diamonds called nitrogen-vacancy (NV) centers. To make NV centers, researchers replace one carbon atom in a tiny diamond crystal with a nitrogen atom and remove a neighboring atom — creating a system that is essentially a nitrogen atom with a hole next to it. NV centers can be used to emit single photons or detect very weak magnetic fields. They have photoluminescent properties, meaning they can convert information into light, making them powerful and promising systems for quantum computing, phontonics and sensing

The team created the NV centers by replacing one carbon atom in a scant diamond crystal with a nitrogen atom and then removing a neighboring nitrogen atom. This created a system that is a nitrogen atom with a hole next to it.

These NV centers can emit single photos or detect weak magnetic fields. The NV centers also have photoluminescent properties.That last bit means that the NV centers can convert information into light allowing them to be powerful and potential systems for quantum computing, photonics, and sensing. Building a radio receiver requires five components including a power source, receiver, transducer, speaker, and a tuner. The device the scientists have created powers the electrons in the NV center with green laser light.

When powered the electrons are sensitive to electromagnetic fields including FM waves. When that audio signal is received it is emitted as red light that can be interpreted by a common photodiode and converted into current

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That current is then turned to sound by a speaker or headphones. An electromagnet can then be used to tune the radio station creating a very robust radio receiver .As Leah Burrows, spokeswoman for Harvard's John A. Paulson School of Engineering and Applied Sciences. Explains:

"Radios have five basic components: a power source, a receiver, a transducer to convert the high-frequency electromagnetic signal in the air to a low-frequency current, a tuner, and a speaker or headphones to convert the current to sound."

With those five components as a starting point, let's consider the inner workings of the tiny radio, where there is a diamond crystal made of carbon atoms.

The researchers replace some of those carbon atoms with nitrogen atoms, and leave a hole next to each one. That nitrogen atom/hole pair, called a nitrogen-vacancy center, basically creates the first two parts of the radio: the power source and the receiver. A green laser pointed at the nitrogen-vacancy center excites the electrons in the diamond. That's the power.

When a radio wave hits those excited electrons around the nitrogen-vacancy center, it's converted into red light. That's the receiver. It's also one of the reasons nitrogen-vacancy centers are so compelling as a building block for tiny machines — they are natural light emitters. An electromagnet near the receiver can change the frequency to which the receiver is sensitive. That's the tuner.

But at that point, your "radio" is just a glowing red light. It still hasn't made any sounds.

For the last step, a common device called a photodiode converts the red light back to an electrical current, and a speaker or pair of headphones grabs that current and broadcasts it as sound.

An electromagnet creates a strong magnetic field around the diamond, which can be used to change the radio station, tuning the receiving frequency of the NV centers. Shao and Loncar used billions of NV centers in order to boost the signal, but the radio works with a single NV center, emitting one photon at a time, rather than a stream of light.The radio is extremely resilient, thanks to the inherent strength of diamond. The team successfully played music at 350 degrees Celsius — about 660 Fahrenheit.

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