THE AUTHOR FILE

Ronald Walsworth

How to use diamonds to image single cells, and how to have a career without ever applying for a job.

Quantum diamond microscopes are one of Ron Walsworth's passions. He is a physicist at the Harvard-Smithsonian Center for Astrophysics (CFA) and in Harvard's physics department. He also works on atomic clocks, quantum science and exoplanets. Some scientists poke fun at colleagues who crisscross fields as he does. "They think they are making fun of them, but actually I think they are making fun of themselves," says Walsworth. "They're missing out on what's going on."

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Ronald Walsworth

Walsworth likes developing and building tools for precise measurements, one of which is the quantum diamond microscope that harnesses special flaws in diamonds. A perfect diamond is transparent to visible light. But when two neighboring carbon atoms in the diamond lattice are replaced with nitrogen in one spot and nothing—a vacancy—in the other, the changed distribution of electrons gives the diamond special properties. Incoming green light is absorbed, and red light is emitted. Given that the electrons also have angular momentum, or spin, each such nitrogen-vacancy (NV) center "will act like it is a little magnet," he says.

The diamond's properties let the microscope detect small changes in magnetic fields, and then "you can read the signals out optically," says Walsworth. In the new instrument, a sample is placed on top of a small, planar diamond chip, which has a high density of NV centers. The intensity of the red light readout depends on the exact magnetic signature at each spot, which corresponds to a camera pixel. "The strength of the light it gives off is a function of the local magnetic field," he says.

Walsworth and his team have built and used the instrument and applied magnetically labeled antibodies to image and quantify rare, single cells, such as tumor cells mixed in with a sample of healthy cells. Magnetic fields penetrate through matter, such as tissue or blood, without suffering from autofluorescence and absorption issues common to optical techniques. The field of view is large in this instrument—1 millimeter by 1 millimeter—and it could be larger still, he says: for example, as large as a microscope slide.

The work was done with colleagues at Harvard and Massachusetts General Hospital. Walsworth credits the idea to physicist Colin Connolly, who is at a company called Quantum Diamond Technologies Inc., for which Walsworth consults. The company is exploring ways to exploit NV centers in diamonds, such as for bioassays and imaging. "The technology is good for finding rare things," says Walsworth. Wherever there are "needle-in-a-haystack problems," diamonds with NV centers have a bright career future.

Walsworth's own career path has been unusual. The last time he sent in an application for anything was to get into graduate school. After receiving his PhD in physics, Walsworth basically never left Harvard. He was invited to be a postdoctoral fellow at the US National Institute of Standards and Technology, but he struck out on his own in some unused Harvard lab space and with Smithsonian Institution funding instead. "It was very easy to come in as a young person and just try things," he says. The grant made him a principal investigator from day one. "I built up a research group from nothing," he says.

Although Walsworth was later offered a staff scientist position at CFA and a faculty post in the Harvard physics department, he does not recommend his path. Looking back, it's a great story to tell, but, he asks, "what the hell was I thinking?" He had just married; his first of four children was on the way.

"I really enjoy that human connection."

As lab head, he believes in clearing the path for young scientists so they can do the work they choose. "Don't just use them as your minions," says Walsworth. He also helps members of his group find jobs in the currently difficult market. He is as scientifically driven as he is gregarious with his group and collaborators. "I really enjoy that human connection," he says.

Walsworth's lab is unique in that it does fundamental physics and builds biomedical tools, says Matthew Rosen, a former postdoctoral fellow in Walsworth's lab. He now has his own biomedical imaging lab at Massachusetts General Hospital and calls Walsworth a mentor, friend and collaborator. "The fact that he is so fun and comfortable around people makes it all the more striking that he is also a brilliantly intuitive and creative physicist," says Rosen, who has known Walsworth for more than 20 years. "I've watched him do more physics on the back of a piece of scrap paper while standing at a BBQ making his famous pineapple chicken sandwiches than many do in a lifetime."

Vivien Marx

Glenn, D.R. *et al.* Single-cell magnetic imaging using a quantum diamond microscope. *Nat. Methods* **12**, 736–738 (2015).