Imaging the magnetic field distributions of chains of magnetic particles using nitrogen-vacancy centres in diamonds

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Nitrogen-vacancy (NV) centres in diamonds have proven to be very useful for measuring magnetic fields [1]. The NV centre has a triplet ground state with a zero-field splitting between the $m_s = 0$ and $m_s = \pm 1$ ground-state sublevels of 2.87 GHz. Moreover, in the presence of a local magnetic field the $m_s = \pm 1$ energies components are shifted by 2.8 MHz/G. Due to a non-radiative decay path via a singlet state that preferentially populates the $m_s = 0$ ground-state sublevel, the NV centre can be polarized optically, and the fluorescence from exciting $m_s = 0$ sublevel is more intense than the fluorescence from exciting the $m_s = \pm 1$ sublevels. As a result, the polarization state can be inferred from the fluorescence intensity. When a thin layer of NV centres is created close to the surface of a diamond, magnetic field distributions at the position of the NV layer can be imaged [2,3]. We have constructed a magnetic field microscope using a Leica DLM inverted microscope and are using it to study magnetic field distributions from magnetic spheres made from different materials and of different sizes. Chains of magnetic particles can be created by various methods. The simplest way is to dry a suspension of ferromagnetic particles in the presence of a magnetic field (see Fig. 1). We have also used strands of DNA to create flexible filaments of ferromagnetic particles coated with streptovidin. Magnetic field images have been made by the method of optically detected magnetic resonance (ODMR), in which the microwave frequency is scanned, and the fluorescence signal shows a minimum when the frequency is in resonance with a $m_s = 0 \longrightarrow m_s = \pm 1$ transition. We report on our experiments to image the magnetic field distributions from these particles and to use the information to infer the magnetic properties of the particles.

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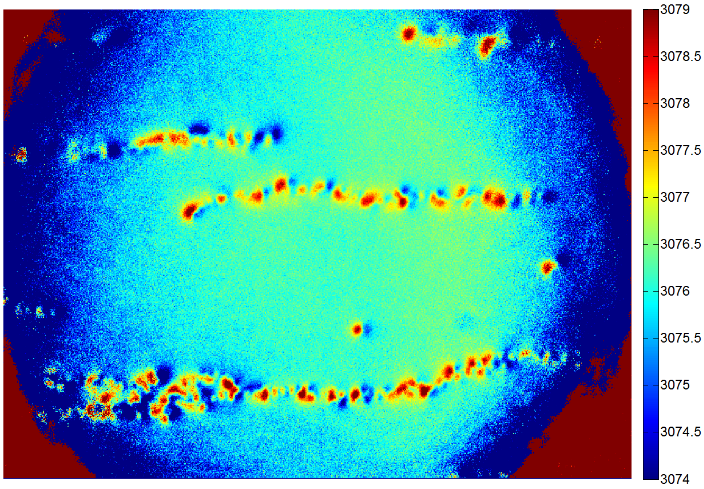

Figure 1: *Image of magnetic field distribution of chains of 4 μm diameter ferromagnetic particles dried in the presence of a magnetic field. The color indicates the position of the ODMR peak for each pixel. A shift of 2.8 MHz corresponds to a magnetic field of one Gauss.*

References

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