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# Magnetically ordered erbium crystals for microwave-to-optical transduction

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A transducer capable of converting quantum states from the microwave domain to the optical domain would greatly enhance the capabilities of superconducting qubits. The long-distance transmission capabilities permitted in the optical domain would allow distributed computing, paving the way for a worldwide quantum internet.

One approach to building a quantum transducer exploits the spatially uniform magnons present in fully concentrated rare-earth crystals. Fully concentrated rare-earth crystals have received little attention for quantum technology applications yet offer unique capabilities due to their strong optical resonances and magnetic interactions.

We experimentally characterised the 1540nm optical transitions of $LiErF_4$, a planar dipolar antiferromagnet that orders at $T_c$=370mK. The spectrum was dominated by strong lines that modify the bulk refractive index of the crystal, as well as magnon sidebands to these strong lines. The observed optical structure was well described by a mean-field magnetic model applied to a single erbium ion. Extraordinarily narrow satellite lines were present in the magnetically ordered phase, with an inhomogeneous linewidth of 18MHz. This is among the narrowest optical inhomogeneous linewidths ever observed in the solid state. The properties of $LiErF_4$ were suitable for quantum transduction, and could support a transduction bandwidth of several megahertz.

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