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Switching a cryo-memory cell in less than half a picosecond

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Cryo-cooled supercomputers and quantum computation are prospective directions of IT development, which both face the same barrier: No high-performance storage memory is available for low-temperature operation. A promising candidate for a future ultrafast memory device is the layered transition metal dichalcogenide 1T-TaS2, which has undergone a recent resurgence of interest with the discovery of a topologically protected stable hidden state [1]. We performed three pulse write-pump-probe experiments and have directly measured the time evolution of the hidden state after the crystal is hit by a laser pulse [2]. In addition, multiple fluence dependent (optical pump-probe and scanning tunnelling microscopy) switching experiments at different temperatures show us a time-resolved phase diagram of the hidden state. We find that the phonon frequency changes in about one oscillation period (˜400 fs), making the material the fastest known switching device. The switching is controllably reproducible and the threshold switching fluence is constant at all temperatures, suggesting that only a sufficient number of induced carriers is important for the transition. The material is of great technological interest especially due to the easy readout of the hidden state, as its resistivity is up to three orders of magnitude lower than that of the virgin state.

[1] L. Stojchevska, et al.; Ultrafast Switching to a Stable Hidden Quantum State in an Electronic Crystal. Science 344, 177 (2014) https://doi.org/10.1126/science.1241591
[2] J. Ravnik, et al.; Real-time observation of the coherent transition to a metastable emergent state in 1T-TaS2. Physical Review B 97, 075304 (2018)
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