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A donor molecule in silicon[1] M. FERNANDO GONZALEZ ZALBA, Hitachi Cambridge Laboratory, DOMINIK HEISS, Technische Universiteit Eindhoven (The Netherlands), ANDREW J. FERGUSON, Cavendish Laboratory (UK), ANDRE SARAIVA, Universidade Federal do Rio de Janeiro (Brazil), MARIA J. CALDERON, Instituto de Ciencia de Materiales de Madrid-CSIC (Spain), BELITA KOILLER, Universidade Federal do Rio de Janeiro (Brazil) — In 1954 Kohn and Luttinger introduced the description for a single donor in silicon as a hydrogen atom analogue in a semiconductor environment. Generalizing the concept, a donor pair may behave as a hydrogen molecule. However, a detailed understanding of the electronic structure of these molecular systems is a challenge to be overcome. Here we present an experimental demonstration of the energy spectrum of a strongly interacting donor pair in the channel of a silicon nanotransistor. We show the first evidence of a simultaneous enhancement of the binding and charging energies with respect to the single donor spectrum as well as a measurable exchange coupling. The measured data can be accurately matched by an effective mass theory incorporating the Bloch states multiplicity in Si, a central cell donor corrected potential and a full configuration interaction. These results suggest a novel physical mechanism to increase the operation temperature of conventional single-atom transistors and improve their robustness against interfacial electric fields. Furthermore, the data describes the Kane basic quantum processing element in the range of molecular hybridization.

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