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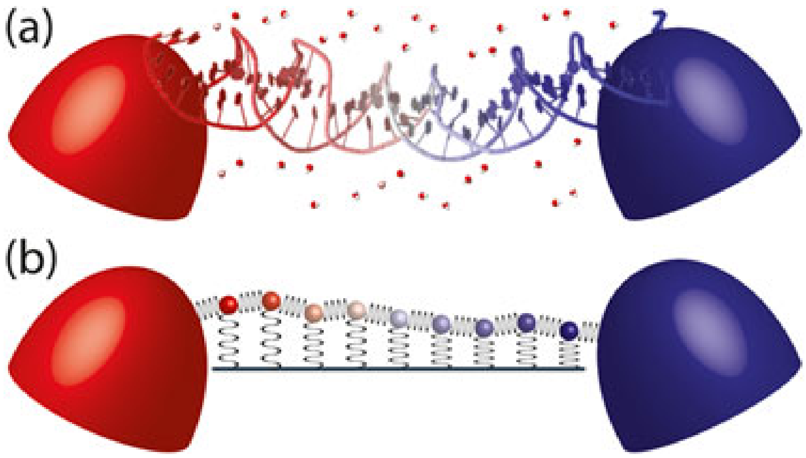
DNA 'heattronics' could make thermal switch

Reporting their results in the journal *Nanotechnology* (http://iopscience.iop.org/0957-4484/24/9/095704/) , researchers have shown that a temperature-controlled "thermal switch" might be made by fine-tuning the properties of a DNA nanojunction.



(http://images.iop.org/objects/ntw/journal/12/3/7/image1.jpg)
Thermal switching near the denaturation temperature
(http://images.iop.org/objects/ntw/journal/12/3/7/image1.jpg)

DNA exhibits fascinating mechanical properties, the most amazing of which is the "denaturation transition". Here, the base pairs unbind and the DNA goes from being a double-stranded molecule to one that is made up of two single strands. This transition occurs at a critical temperature threshold (typically around 70 °C) and is relevant for biological processes, such as transcription and replication. However, understanding the phenomenon is a great scientific challenge because it is the only example of a phase transition driven by non-linearity in a quasi one-dimensional nanoscale system.

One-dimensional nanoscale systems are the focus of a research branch known as phononics: the control of heat transport in nanoscale devices. Studies on DNA nanophononics suggest that the non-linear properties of DNA denaturation can be exploited to control heat flow in the molecule. Our team, which includes scientists from the Los Alamos National Laboratory in the US, Ben-Gurion University in Israel, and Oregon State University, also in the US, used a theoretical model for DNA to show that the thermal conductance of a DNA junction significantly increases as the denaturation transition is crossed. Related experiments have shown that nonlinear changes in thermal transport through DNA devices indeed occur thanks to the denaturation transition.

We have now demonstrated that we can tune the thermal conductance of a DNA nanojunction (such as base-pair sequence and DNA chain length) as the denaturation transition temperature is crossed. The thermal conductance can thus be engineered to be very low (the "off" state) below the denaturation transition and very high (the "on" state) above the transition, which makes for a temperature-controlled "thermal switch". Even the switching temperature can be tuned via the sequence of bases in the DNA strand.

More details (http://iopscience.iop.org/0957-4484/24/9/095704/) of the work can be found in the journal *Nanotechnology*.

About the author

The study was conducted by four researchers from the Los Alamos National Laboratory (LANL), Ben-Gurion University, Israel (BGU), and Oregon State University (OSU). The research group was formed when all of the scientists were postdoctoral scholars at LANL, and they continue to collaborate. Chih-Chun Chien is an Oppenheimer postdoctoral fellow at LANL, working in the Condensed Matter and Complex Systems Theory group. Kirill Velizhanin is currently a staff member at LANL, working in the Theoretical Physics and Chemistry of Materials group. Yonatan Dubi is a faculty member at BGU's Chemistry Department and Michael Zwolak is a faculty member in OSU's Physics Department.

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