Chilling Results for MURI Effort

Using AFRL Multidisciplinary University Research Initiative funds, researchers created the first solid-state cryocooler (pictured) that can be applied to airborne and spaceborne sensors. The technology enabling this new capability is known as optical refrigeration. (Photo Credit: Mansoor Sheik-Bahae, UNM)

Thanks to AFRL Multidisciplinary University Research Initiative (MURI) funding, a team led by University of New Mexico (UNM) professor Dr. Mansoor Sheik-Bahae created the first solid-state cryocooler capable of airborne and spaceborne sensor application. Also known as optical refrigeration, this technology—which facilitates temperatures so cold they are achievable only through the liquefaction of gases—may prompt superconducting electronics advances based on its capacity to leverage miniaturized designs for cooling purposes.

Collaborating with researchers from Los Alamos National Laboratory (LANL) and the University of Pisa (UP), Italy, UNM graduate students Denis Seletskiy and Seth Melgaard designed and performed the cryocooler experiments at the university's Physics and Astronomy Department facilities. Whereas standard thermoelectric devices have enabled conventional solid-state coolers to reach temperatures as low as 170 K (with minimal efficiency), the researchers obtained cooling results down to 155 K using optical refrigeration. Further, they anticipate that additional materials research could produce temperatures dipping below 77 K (the boiling point of liquid nitrogen) and speculate that future efforts may yield plunges to 10 K. To achieve their recent breakthrough, the team members enhanced cooling efficiency by exploiting resonances in the absorption spectrum, growing pure crystals, using thin optical fibers, thermally isolating the sample inside a vacuum, and trapping laser light in a resonant space.

Because it is a vibration-free (no moving parts), compact, lightweight, and agile (fast turn-on/turn-off) technology, solid-state optical refrigeration affords many advantages over currently used, bulky mechanical coolers. Accordingly, Dr. Sheik-Bahae and his team plan to continue their research collaborations both with Professor Mauro Tonelli and his UP cohort and with LANL's Dr. Richard Epstein. Together, the group intends not only to investigate product purity and new cryocooler materials, but to pursue optical pump sources for further improvements in device cooling efficiency.