Progress toward a kilopixel time-division multiplexer for IXO’s X-ray Microcalorimeter Spectrometer

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Abstract: The X-ray Microcalorimeter Spectrometer instrument for ESA/JAXA/NASA’s proposed International X-ray Observatory will employ a kilopixel-scale array of transition-edge sensors (see poster 457.12). A candidate technology for the readout of the array is NIST’s time-division SQUID multiplexer. In this architecture, the TESs are dc biased, and produce a current pulse whose height is proportional to the energy of the incoming X-ray. Each TES is coupled to its own first-stage SQUID ammeter. Rows of first-stage SQUIDs are turned on one at a time. The signal from the active row in each column is passed to a series-array SQUID amplifier, and then to a room-temperature amplifier. A suite of digital-feedback electronics maintains each first-stage SQUID in a linear portion of its sinusoidal flux-to-voltage transfer curve. Versions of this architecture are in use in several kilopixel-scale TES bolometer instruments, including ACT and SCUBA-2.

Multiplexed readout is typically more difficult for TES microcalorimeter arrays than it is for TES bolometer arrays, due to the relative speed and dynamic range of the signals. We have recently demonstrated the readout of an array of NASA/GSFC high-resolution x-ray TESs through the NIST multiplexer. The detectors have fast time constants (about 280 μs), which is in the range being discussed for IXO. Results from these experiments include sub-3 eV average energy resolution in a 2-column x 8-row demonstration.

Recent result: ΔE < 3 eV in 16 multiplexed pixels
Below: 64 pixel GSFC TES array in NIST 4x32 SQUID TDM.
Right: Mn Kα lines, characteristic of a 55Fe radioactive source, observed by 16 of these detectors (2-column x 8-row MUX) simultaneously. ΔE_{FWHM} was 2.93 ± 0.02 eV. Detector time constants were 280 μs, in the range of what is being discussed for IXO’s XMS instrument. Each row was “on” for 680 ns. In the full IXO core array, this will be reduced to about 160 ns.

Future directions
The full IXO core array will be 40 X 40 pixels.
Our next planned milestone is a 96-pixel (3-column X 32-row) demonstration of IXO-like pixels.
Planned upgrades to the system include faster digital-feedback electronics, reduction of the SQUID noise by half and an increase in the open-loop bandwidth from 1.5 MHz to about 10 MHz.