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Clover - a B-mode polarization instrument

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The polarization of the cosmic microwave background (CMB) contains unique information about the early universe. In particular, the presence of a tensor (gravitational wave) component, which is degenerate with other parameters in its effect on the temperature anisotropies, produces a unique signature in the CMB polarization, the *B*-mode signal. The polarization field can be decomposed into curl-free (*E*-mode) and curl (*B*-mode) components, and the polarization from scalar anisotropies produces no *B*-mode. Provided spurious sources of *B*-mode signal (such as foregrounds and systematic effects) can be controlled, detection of a *B*-mode signal would thus constitute a direct measurement of primordial gravitational waves and would measure fundamental parameters of inflation theory. However, the expected amplitude of the signal is exceedingly small (< 0.1μK) and very precise control of systematic effects, as well as raw sensitivity, will be needed to measure it reliably.

Clover is a project to attempt to measure the *B*-mode polarization of the CMB. It consists of three separate, scaled instruments operating at 90, 150 and 230 GHz to provide discrimination between the CMB and foregrounds. At each frequency, four co-aligned telescopes are mounted around a single cryostat, and can be pointed in azimuth-elevation as well as being rotated about the pointing axis. The telescopes use the Compact Range Antenna design, which has particularly low aberrations across a large focal plane. The telescope focal planes will be populated with arrays of pseudo-correlation polarimeters, in which the orthogonal polarizations from each pixel are phase-switched, recombined and detected so as to extract the Stokes parameters *Q* and *U*, modulated by the phase switch frequency. Intensity can also be recovered, but only modulated by the telescope scanning across the sky. The signals will be detected using arrays of superconducting transition edge sensors (TESs), which allow background-limited sensitivity and can be fabricated in sufficient quantity using lithographic techniques.

It is planned to site Clover at Dome C, at latitude -75 deg in Antarctica, where the atmospheric transparency and stability are excellent, and the latitude allows for constant-elevation scans of a single sky area to be cross-linked. The beamwidth at each frequency will be 15 arcmin and the telescopes will be scanned to give sensitivity over an angular multipole range of $5 < l < 500$. This will allow measurement of the *B*-mode signal over the range of scales expected for the signal from primordial gravitational waves. The sensitivity should be around 220 μK $s^{1/2}$ per pixel at 150 GHz, sufficient for the sensitivity to be limited by the *B*-mode lensing foreground after 2 seasons of observation. This will result in a sensitivity to a gravitational waves equivalent to a tensor-to-scalar ratio *r* of $r > 0.004$.