Observations of the hot gas in clusters of galaxies with Diabolo through the Sunyaev–Zel'dovich effect

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Abstract

The SZ effect is a distortion of the Cosmic Microwave Background by the inverse Compton effect on the hot intracluster electrons. It has a negative peak at 2.1 mm which is the most sensitive channel of the dual-channel large throughput 0.1 K bolometer Diabolo instrument. Detection of this effect in several clusters would allow direct measurements of the gas content of clusters. Moreover, estimates of the Hubble constant, the peculiar velocity and the total mass of clusters are within reach, which are all of important cosmological relevance. The 30 meter IRAM radiotelescope is unique in giving a large angular resolution and allowing to make maps of the SZ effect that can be compared with centimetre interferometric data. The diabolo experiment has proved to be a testbed for the 0.1K dilution cryostat that is the nominal solution for FIRST and PLANCK missions, as well as the electronic AC modulation of the bolometers (see Gaertner et al. this conference).

OVERVIEW

Following the submillimetre scientific and technical developments made for the balloon–borne SPM photometer on board the PRONAOS 2m telescope, we have designed a two-channel millimetre photometer (Diabolo) for ground–based telescopes: so far we have observed at MITO 2.7m Testa Grigia (Italy), IRAM 30m Pico Veleta (Spain), and POM2 2.5m Plateau de Bure (France). The Diabolo instrument (Benoit et al 1997) is primarily designed for the measurement of the Sunyaev-Zel'dovich (SZ) effect, the inverse Compton scattering of the Cosmic Microwave Background by the hot electrons in clusters of galaxies. Tentative detection of the SZ effect at the 30m IRAM telescope in December 1995 in several high redshift clusters at very high angular resolution (30 arcseconds with 3 arcmin wobbling) will be shortly reported (Désert et al. 1997). The 2 bolometers (designed by the bolometer group at IAS led by N. Coron) working at 1.2 and 2.1 mm are cooled down to 0.1K by a compact dilution fridge that is compatible with space–applications, mainly ESA missions FIRST and PLANCK surveyor (Benoit et al. 1994). The 1.2 mm beam is co–aligned and co–extensive with the 2.1 mm beam. It is mainly used to monitor and thus subtract the water vapour sky noise (dominant source of noise). The first use of the complete dilution fridge which can directly start from the 4K stage was used for astrophysical observations on the 30m last December 1996 run. This alleviates the need for pumping the liquid helium in the cryostat, thus an autonomy of more than 3 days has routinely been achieved with interruptions of observations of only half an hour for liquid helium refilling. The open cycle dilution fridge can run without interruptions for months or even years (3 continuous weeks in observations at POM2 have already been tested in March 1997). Another important aspect of the instrument is the new AC square wave modulation of the bolometers (Gaertner et al. 1997). This could prove essential for observations that require total power mode, including Planck Surveyor, possibly FIRST BOL instrument and it has been successfully tested with Diabolo (February and March 1997) on nearby clusters with large angular extent with POM2 2.5m telescope (Observatoire de Grenoble) in drift scans that do not cut any particular angular frequencies.

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