THE SZ COSMOLOGICAL PROJECT: NEW RESULTS AND FUTURE PROSPECTS

S. COLAFRANCESCO[1], M.DEPETRIS[2], F. MELCHIORRI[3], L.LAMAGNA[2], A. DEMICCO[2], A. ORLANDO[2], F. ROMANO[2], Y. REPHAELI[3], M. SIGNORE[4], G. ZALAMANSKY[4] and E. KREYSA[5]

1) Osservatorio Astronomico di Roma - ITALY

2) Dip. di Fisica, Univ. La Sapienza, Roma - ITALY

3) Tel Aviv University, Tel Aviv, ISRAEL

4) Observatoire de Paris, Paris, FRANCE

5) Max Planck Inst. für Radioastronomie, Bonn, GERMANY

We describe the aim and the capabilities of the SZ Cosmological Projects (SZCP) which is bound to construct a sample of ~ 30 nearby clusters with measured values of Comptonization parameter. We present the preliminary results on the detection of an SZ effect in Coma obtained, within the SZCP, at three frequencies (148, 219 and 269 GHz) and we briefly discuss its cosmological and astrophysical relevance.

1 The SZ Cosmological Project

The main aim of the SZ Cosmological Project is to derive a sample of ~ 30 nearby clusters with measured values of the Comptonization parameter, y, in a period of ~ 3 years (2000 - 2003) to be used for cosmological studies. With this sample of nearby clusters we can test structure formation scenarios using the sensitivity of the cluster space density, we can determine H_0 from a statistical sample of clusters with good SZ and X-ray data and we can test cluster astrophysics at sub-mm frequencies.

To accomplish this project, we make use of the MITO telescope located at the Testa Grigia Observatory (Longitude: $7^o\ 42'$ E; Latitude: $45^o\ 56'$ N) at an elevation of 3488 a.s.l. near Cervinia - Italy (see DePetris et al. 1996). This telescope with a 2.6-m primary mirror has been optimized for spatial differential measurements by a secondary mirror (41-cm in diameter) with a maximum modulation of $\Delta\theta = 1$ deg. The telescope is equipped with a 4-channels (1-pxl) photometer with sensitivities in each channel given in Table 1.

Table 1: MITO sensitivities for SZ signals

	148 GHz	219 GHz	269 GHz	316 GHz
$nV/\sqrt{Hz}$	10	11	8	27
$mK/\sqrt{Hz}$	2.7	1.8	0.9	2.3
$y_{obs}/\sqrt{Hz}$	9.0×10^{-4}	7.1×10^{-3}	9.1×10^{-4}	1.6×10^{-3}

For the first year of operation we selected a sample of 13 clusters based on their observability from Testa Grigia, their expected signals and the availability of detailed X-ray informations.

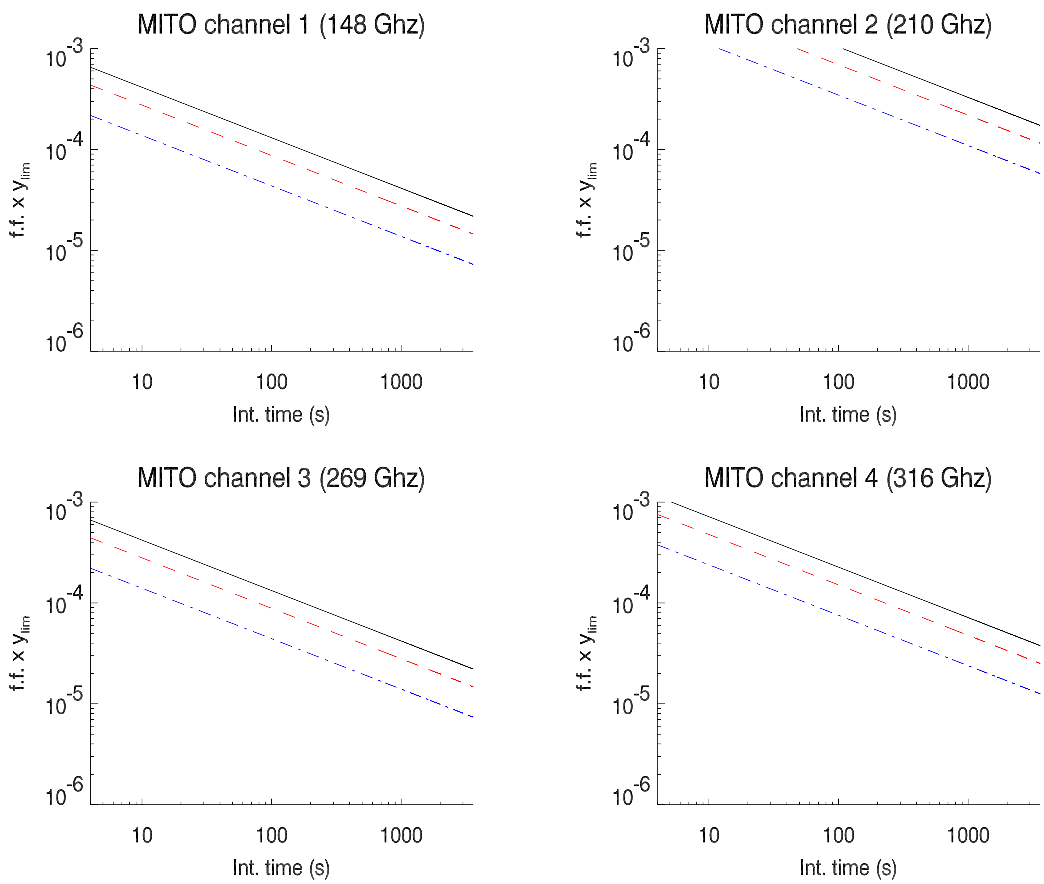

Figure 1: Sensitivities for SZ cluster signals detected at levels: S/N=1 (dot-dashed), 2 (dashed) and 3 (solid) in each of the four channels of the MITO bolometer system.

2 New Results

To show the feasibility of the SZ observations with the MITO telescope, we present here a new determination of the SZ decrement toward the Coma cluster. The Coma cluster has been extensively observed at different wavelenghts from radio to X-rays. The X-ray data at $E \sim 0.1 - 10$ keV allow to test the physical status and the distribution of the thermal electrons at temperature of $T \sim 8.2$ keV. These thermal electrons are spatially distributed according to a β-profile with a core radius of $r_c = 0.42$ Mpc (10.84 arcmin at the redshift of Coma, z=0.023) with $\beta = 0.75$ (we use here $H_0 = 50$ km s^{-1} Mpc^{-1}). This thermal distribution of electrons has a suprathermal tail (Dolgiev 1999) which extends ta least up to $E \sim 100$ keV and produces an hard X-ray excess over the thermal bremsstrahlung emission observed at energies $20-80$ keV (Fusco-Femiano et al. 1999, Rephaeli et al. 1999) with a luminosity $L_{20-80} \sim 0.045 L_{2-10}$. Another non-thermal population of high energy electrons is embedded in the Coma intracluster medium and produces - via synchrotron emission - an extended radio halo with an average spectrum, $J(\nu) \sim \nu^{-1.16}$, in the frequency range $30-1400$ MHz (Feretti 1999). The non-thermal origin of the EUV excess in Coma would require the same population of relativistic electrons to emit EUV photons via Inverse Compton Scattering with the CMB photons, but the origin of the EUV excess is still unclear.

Coma has been also a target for SZ observations mainly in the Rayleigh-Jeans region and Herbig et al. (1995) reported a detection at the level of $y = (9.3 \pm 1.7) \times 10^{-5}$ at a radio frequency of 32 GHz.

2.1 MITO observation of Coma

Coma has been observed with MITO in May '98 with 8 minutes long 12 drift scans. Here, for the sake of brevity, we only report the first detection of a SZ effect at three frequencies (148, 219 and 269 GHz), applying a spectral decomposition model with spatial information of the expected source due to the few integration time on source. The large residuals suggested us to dedicate much more time on source and this has been done during the winter 1999-2000 and the data reduction is still going on. We refer to DePetris et al. (2000a,b) for the discussion of the techniques for calibration and data analysis. The SZ effect detected in Coma is consistent with a central value of the Comptonization parameter $y \sim 1.5 \times 10^{-4}$ or equivalently $(\Delta T/T)_{RJ} = -3.0 \times 10^{-4}$. The large residuals in the data analysis might indicate the possible presence of some source of systematic uncertainty which could increase the true statistical uncertainties in the final result. Our second run of observation will have an integration time of more than 10 hours and will provide more secure results.

Several sources of confusion (CMB anisotropy, SZ distorsion from randomly distributed background clusters, doppler distorsions of CMB due to high-v gas-rich spiral galaxies in the cluster, Galactic free-free emission) have been considered and the result given here can be considered as fairly realistic. Moreover, biases from discrete radio sources, diffuse radio halo emission, thermal dust emission from the cluster and free-free emission from warm gas ($T \sim 10^4 - 10^6$ K) in the cluster do not significantly affect the result.

Nonetheless, because Coma contains also a population of high-energy electrons producing the radio halo, we also consider the relevance of a non-thermal SZ effect (here we present the basic results of this study and a more extended discussion is given in Colafrancesco 2000) in Coma due to Compton scattering of CMB photons with the high energy electrons in the intracluster space of Coma. The relative importance of the non-thermal SZ effect due to the population of relativistic electrons compared to the thermal SZ effect depends on the ratio between the pressures in the non-thermal ($P_{rel} \approx E/3$) and the thermal ($P_{th} \sim nkT$) electron populations. The spectral shape of the measured SZ effect from Coma, consistent with the result given here, requires that the contribution of the non-thermal SZ effect in Coma is $\lesssim 10\%$. Note that a spectral coverage from ~ 100 GHz to $\gtrsim 400$ GHz, as obtained with MITO, is crucial to constrain the relevance of non-thermal SZ effect in clusters.

3 Future Prospects

The observability conditions at Testa Grigia give an available number of nights (year)$^{-1}$ of $80-120$, and our baseline for Coma gives us an estimate of the required nights (cluster)$^{-1}$ $\gtrsim 12$). Thus, we could observe $\sim 6-10$ SZ clusters per year with a S/N ratio > 3 in the three channels of the photometer. With this feasibility, we could reach the goal of constructing a sample of $\sim 20-30$ nearby clusters in three years.

The selection of clusters is made also on the basis of the $y-T$ correlation given by Cooray (1999). With the actual performances shown here, the SZCP could produce in 3 years one of the largest samples of nearby SZ clusters up to that date. Detailed X-ray observations of such a homogeneous sample of nearby clusters have already been scheduled with XMM, Chandra and BeppoSAX. Thus, we may both test structure formation scenarios through the space density of nearby clusters and we may derive a statistically weighted value of H_0 with an uncertainty of $\sim 10\%$.

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