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Observation of the Sunyaev-Zel'dovich Effect toward CL0016+16 at 43 G Hz

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Abstract. We performed a mapping observation of the Sunyaev-Zel'dovich effect toward a galaxy cluster, CL0016+16, at 43 GHz using a newly developed 6-beam receiver installed in the Nobeyama 45-m telescope. The temperature decrement of the CMB was measured to be $\Delta T_A^* = -0.49 \pm 0.06$ mK at the center of the cluster. Fitting the isothermal, spherical-symmetrical β -model to the observed temperature decrement distribution, the S-Z effect at the center is inferred to be $\Delta T_{RJ}(0) = -1.0 \pm 0.1$ mK at the Rayleigh-Jeans limit. This suggests that the Hubble constant is $H_0\{q_0 = 0.5\} = 67^{+16}_{-11}$ km s^{-1} Mpc^{-1}.

1. Introduction

It is now possible to measure the S-Z effect (Sunyaev & Zel' dovich 1972) both with a single-dish radio telescope and a mm-wave interferometer. Recently, the interferometer becomes a most powerful tool for the mapping observation of the S-Z effect (e.g. Carlstrom et al. 2000). However, the interferometers should not obtain the low-order spatial Fourier components of the S-Z effect which is extended over the X-ray image. Therefore, it is still important to observe the S-Z effect with a single-dish radio telescope at least until the dedicated wide-field interferometer comes into operation. 2) The foreground and/or background source contaminations are steeply decreased in the mm-wave range because the synchrotron emissions drop steeply. In addition, the 40-GHz band is also a "window" of atmosphere.

2. Observations

We observed the S-Z effect toward a galaxy cluster, CL0016+16 ($z = 0.5455$, X -ray position by Einstein IPC; $\alpha_{1950} = 00^h16^m42^s, \delta_{1950} = 16^\circ18'44''.5$; Hughes & Birkinshaw 1998), at 43 GHz with the Nobeyama 45-m telescope during fine nights in 1998 Dec.,1999 Feb., and 1999 Dec.. The receiver frontend was a newly developed 6-beam SIS receiver (Tsuboi et al. 2000). The system noise

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temperature including atmosphere effect was about 150 K during the observations. Calibration of the antenna temperature was made by the chopper-wheel method. Observations were made using a "symmetrical" beam-switching scheme (Birkinshaw & Gull 1984). The frequency of the beam-switching is 15 Hz. The beam-throw is $6'30''$ in the azimuth direction. The telescope is simultaneously position-switched in 8 s interval.

3. Results and Discussion

We obtained the radial distribution of the antenna temperature decrement for the S-Z effect, $\Delta T_A^*(\theta)$. The observed decrement at the center position is $\Delta T_A^*(0) = -0.49 \pm 0.06$ mK. The decrement shallows as it goes outside from the center position. The extent of the decrement is about 130" at FWHM. The S-Z effect at the R-J limit is estimated to be $\Delta T_{RJ}(\theta) = \Delta T_A^*(\theta)/(\xi/2)\eta_{MB}\eta_C$, where η_C is the coupling efficiency between the antenna beam and the S-Z effect for $\beta = 0.75$ and $\theta_C = 42$"(Hughes & Birkinshaw 1998), $\eta_C = 0.8$, η_{MB} is the main beam efficiency, $\eta_{MB} = 0.8$, and $\xi/2$ is the correction factor for the R-J limit, $\xi/2 = x^2e^x[x\coth(x) - 4]/[e^x - 1]^2$. Fitting the isothermal, spherical-symmetrical β-model to the observed distribution, the S-Z effect at the R-J limit is inferred to be $\Delta T_{RJ}(0) = -1.0 \pm 0.1$ mK. Thus, the Comptonization parameter of CL0016+16, y, is estimated to be $y = -\Delta T_{RJ}(0)/T_0 = 1.8 \times 10^{-4}$. A combination of this S-Z effect and the X-ray surface brightness of CL0016+ 16 ($\beta = 0.75, \theta_C = 42", T_g = 7.6$keV, and $\Lambda_0 = 2.7 \times 10^{-13}$ counts /s/cm^5; Hughes & Birkinshaw 1998) suggests that the Hubble constant is $H_0\{q_0 = 0.5\} = 67^{+16}_{-11}$ km s^{-1} Mpc^{-1}. The present values of $\Delta T_{RJ}(0)$ and H_0 are consistent with the previous results for CL0016+16 (e.g. Reese, E. D. et al. 2000).

References

Birkinshaw, M. & Gull, S. F., 1984, MNRAS, 206, 359

Carlstrom, J. E. et al., 2000, Physica Scripta, 85,148

Hughes, J. P. & Birkinshaw, M., 1998, ApJ, 501,1

Reese, E. D. et al. 2000, ApJ, 533, 38

Sunyaev, R. A. & Zel' dovich, Ya. B. 1972, Comments Astrophys. Space Phys. 4, 173

Tsuboi, M. et al. in Proc. of SPIE Conf. Ser. vol. 4015, Radio Telescopes, 278