The Observations of Relic Radiation as a Test of the Nature of X-Ray Radiation from the Clusters of Galaxies

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*CoASP, 1972, **4**, 173*

The velocity of clusters of galaxies relative to the microwave background - The possibility of its measurement

R. A. Sunyaev and Ya. B. Zel'dovich

*MNRAS, 1980, **190**, 413*

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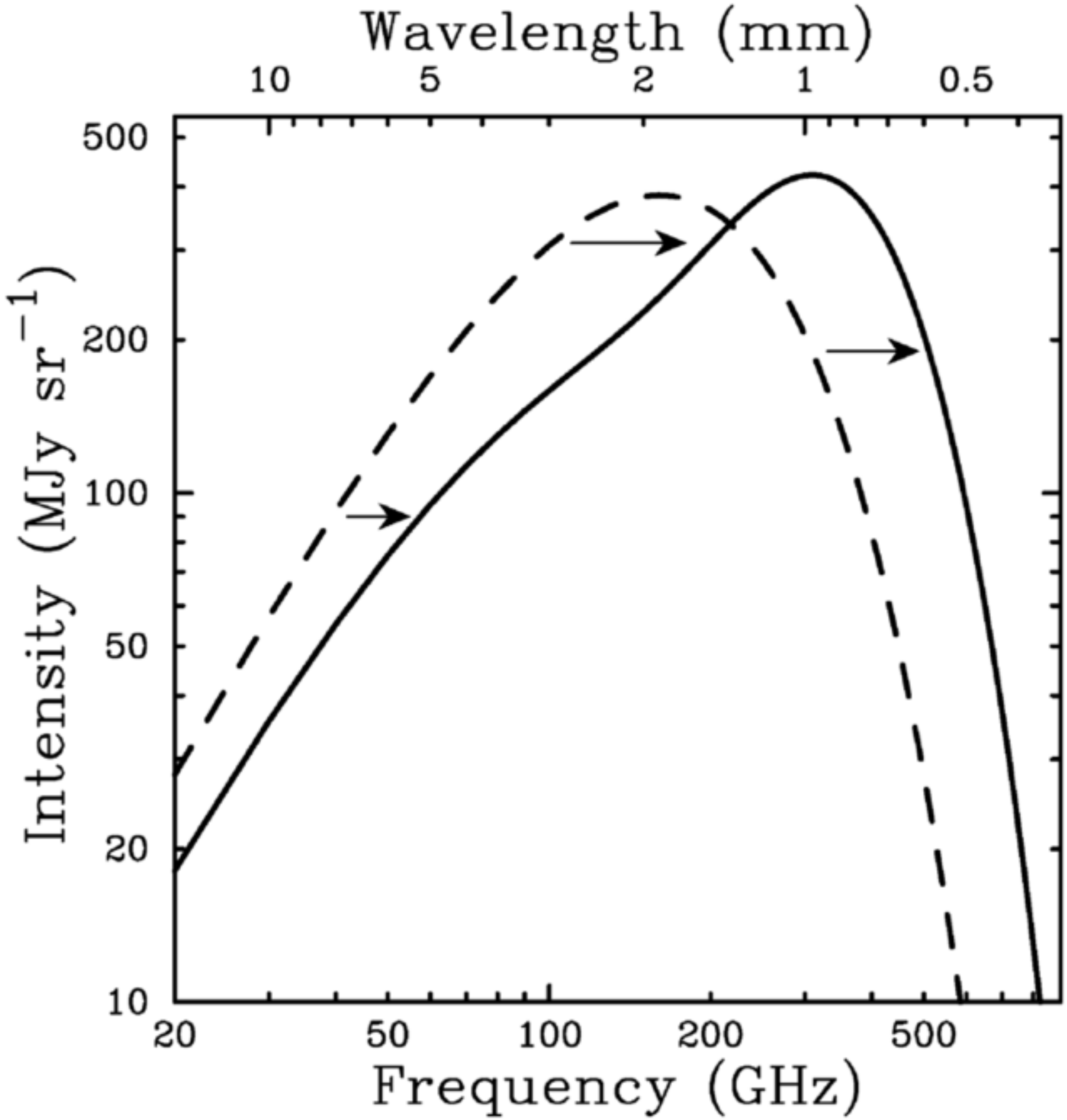


Carlstorm et al. 2002

tSZ effect

$$\frac{\Delta T}{T} = y\left(x\,\frac{e^x+1}{e^x-1} - 4\right)$$

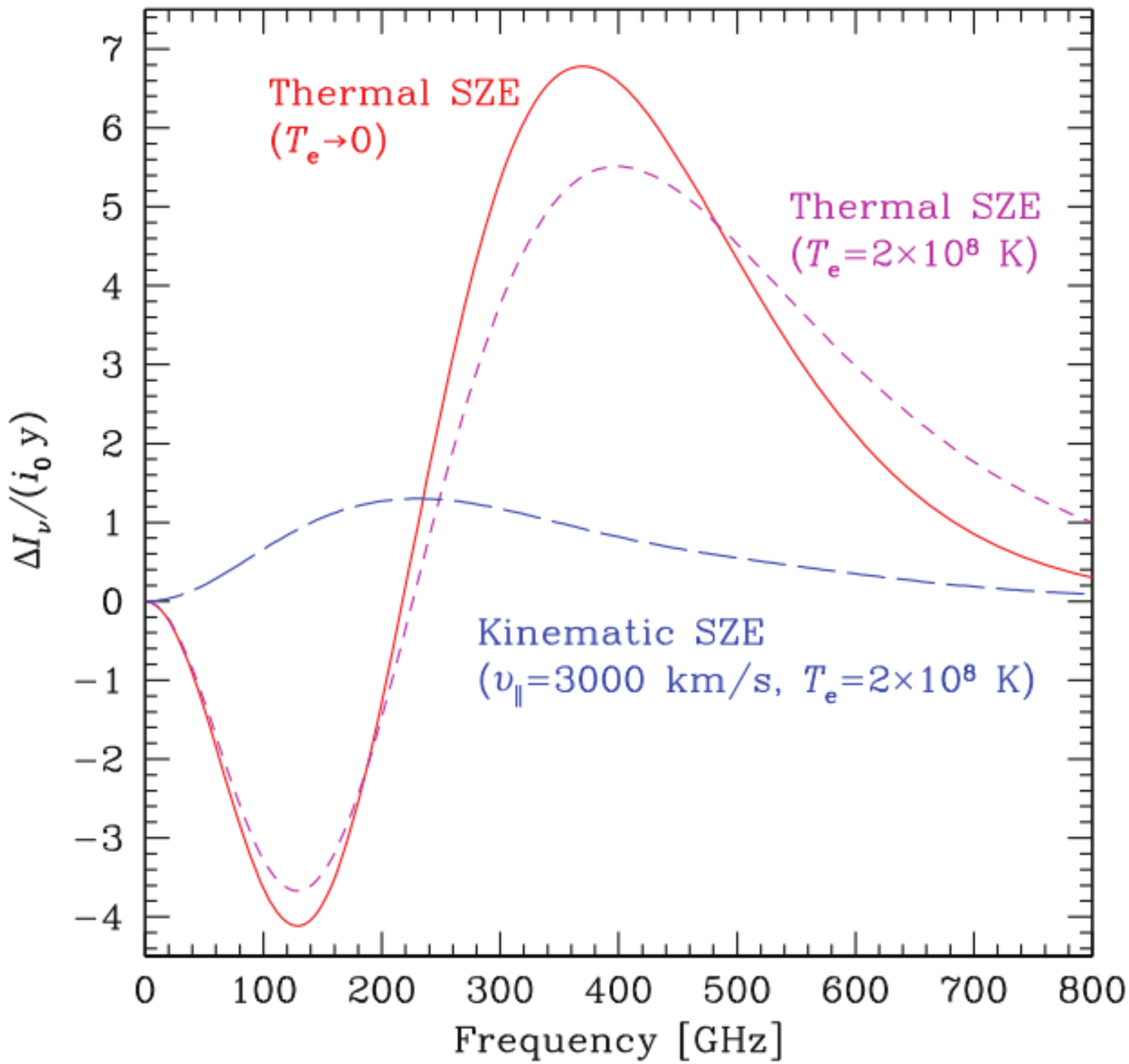
$$\simeq -2y \quad \text{for } x \ll 1\,,$$

$$y \equiv \sigma_T \int dl\, \frac{n_e k(T_e - T_{\rm CMB})}{m_e c^2}\,,$$

kSZ effect

$$\Delta T/T = -b,$$

$$b \equiv \sigma_T \int dl\, n_e \frac{v_r}{c}$$



Kitayama 2014

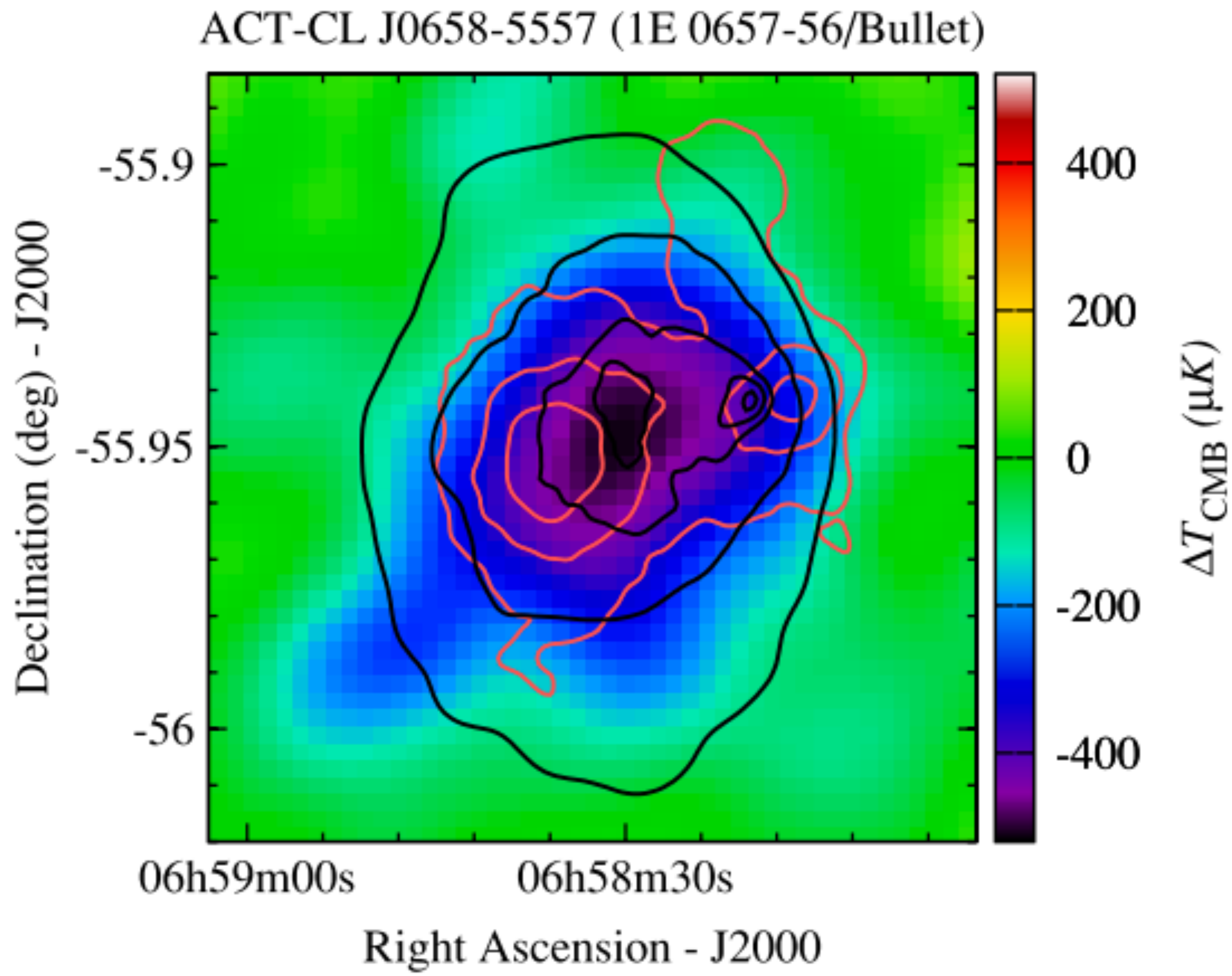


Figure 10. ACT-CL J0658−5556 (Bullet Cluster) with overlaid contours of X-ray emission (black) and dark matter distribution (orange). The X-ray contours come from an 85 Ks long *Chandra* observation (ObsId 3184) and correspond to the 0.5–2.0 keV band. Contour values are 4×10^{-7} to 2×10^{-9} photons cm^{-2} s^{-1} $arcsec^{-2}$. The lensing data are from Clowe et al. (2007) with contours running from $\kappa = 0.12$ to 0.39.

(A color version of this figure is available in the online journal.)

Hincks et al. 2010

Calculation of degree of polarization (Paper II Sec. 3)

Polarization by single electron (Sec 3.1)

$$I'(\mu') = I(\mu')(1-\tau) + \tau\left[I_0 + \frac{1}{10}I_2\left(\mu'^2 - \frac{1}{3}\right)\right]$$

$$= I(\mu') - \tau\left[I_1\mu' + 0.9I_2\left(\mu'^2 - \frac{1}{3}\right) + \sum_{n=3}^{\infty} I_n P_n(\mu')\right], \quad (5)$$

$$Q'(\mu') = \frac{1}{10}\tau I_2(1-\mu'^2), U'(\mu') = 0. \quad (6)$$

Polarization by finite optical depth (Sec 3.2)

$$Q'_\nu = \frac{1}{20}(X\cos\psi - Y\sin\psi)\sqrt{1-(X^2+Y^2)}\beta_t \tau_0^2 I_\nu f(x), \quad (30)$$

$$U'_\nu = \frac{1}{20}(X\sin\psi + Y\cos\psi)\sqrt{1-(X^2+Y^2)}\beta_t \tau_0^2 I_\nu f(x), \quad (31)$$

Sazonov and Sunyaev 1999

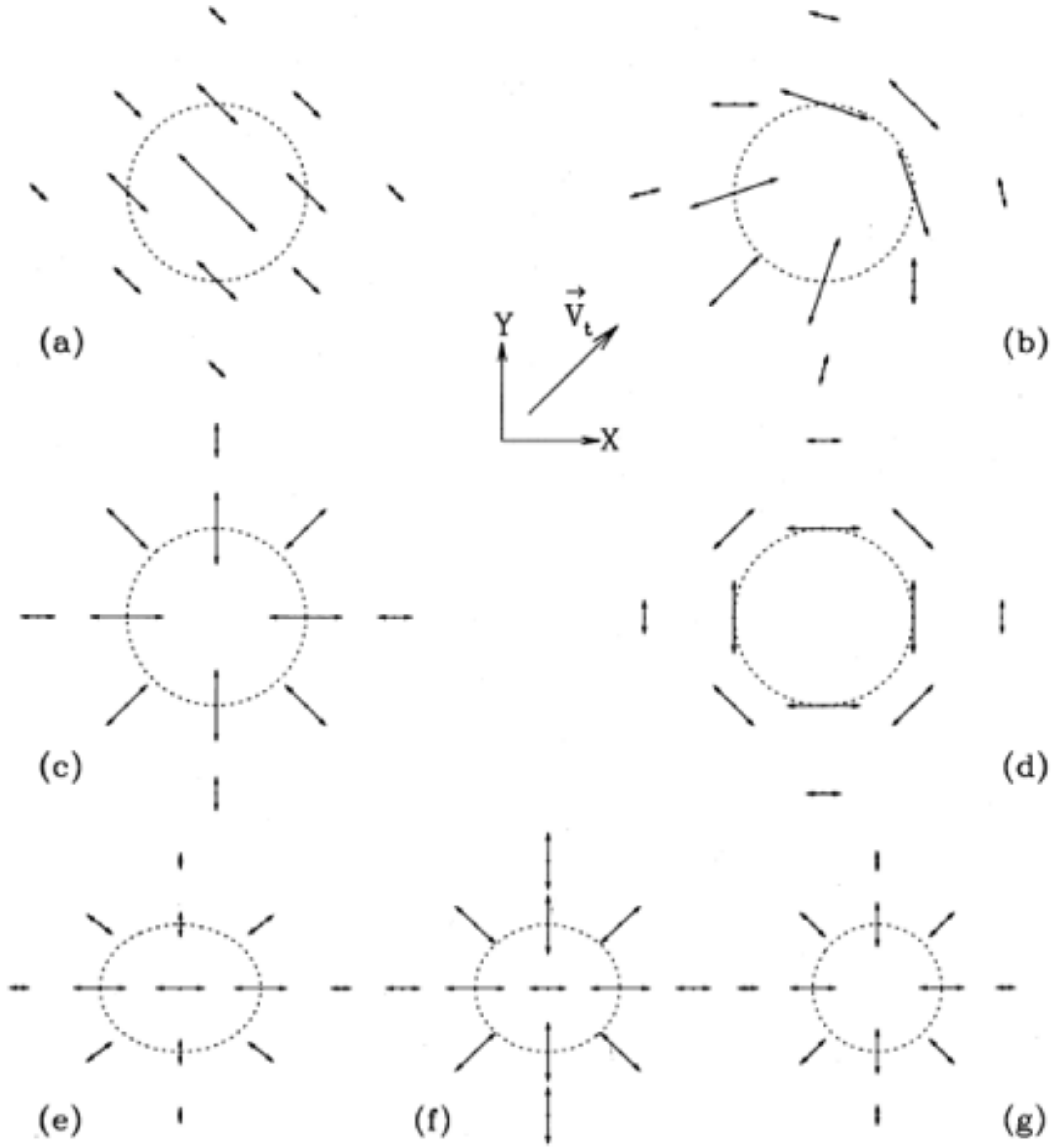


Figure 2. Predicted angular distributions of the polarized signal in the direction of galaxy clusters. In cases (a)–(d) the model gas cloud is spherical and an isothermal density law with $n = 3/2$ is assumed. (a) The polarization $\propto \beta_t^2 \tau$ caused by the peculiar motion in the indicated direction (see the insert in the centre of the figure). (b) The finite optical depth polarization $\propto \beta_t \tau^2$ for the same peculiar motion. (c) The finite optical depth polarization $\propto (kT_e/m_e c^2)\tau^2$ at frequencies $x < 3.83$. (d) The same but at $x > 3.83$. (e) The gas cloud is a spheroid with the ratio of the principal axes $b/a = 0.8$ and the symmetry (longer) axis in the x direction. (f) The same but the symmetry axis is inclined at 45° to the picture plane. (g) The same but the symmetry axis points along the line of sight. The projected core of the cluster (as defined by the isothermal law) is shown by the dashed lines in all panels.