CIB and extragalactic point source polarisation power spectrum

Prospective « Future CMB measurements »
Paris, Feb the 4th

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….. work in progress …

Why a polarisation term if random orientations?

We can define the complex linear polarisation of a source:

$$P_s = \Pi exp(2i\psi)$$

Π degree of polarisation

ψ angle of polarisation

If the polarisation angles of different sources are uncorrelated then:

$$< P_s >= 0$$

but the variance:

$$\sigma_P^2 = \frac{1}{\pi}\int_0^{\pi}(P_s - < P_s >)^2 d\psi = \Pi^2$$

Three components

- Cosmic Infrared Background:
  - 1-halo term: correlation of two different galaxies in the same DM halo (pairs of galaxies inside the same halo)
  - 2-halo term: galaxy correlations in different DM haloes, describes the large-scale clustering
- Dusty star-forming galaxy shot noise (as the 1-halo term does not include the contribution arising from self-correlations of galaxies with themselves)
- Radio galaxy shot noise (e.g., Tucci+2004)
  - Clustering of radio galaxy negligible (e.g., Toffolatti +2005)

Shot noise

- Power spectrum of Poisson-distributed sources:

$$C_l^{TT} = \int_0^{S_c} S^2 \frac{dN}{dS} dS$$

- Equivalent expression for the polarisation spectrum:

$$C_l^{P} = \int_0^{P_c} P^2 \frac{dN}{dP} dP$$

- The emission will on average contribute equally to EE and BB:

$$C_l^{EE} = C_l^{BB} = \frac{1}{2} C_l^{P}$$

- Power spectrum due to sources with a given fractional polarisation:

$$C_l^{P}(\Pi) = \int_0^{\Pi S_c} P^2 \frac{dN}{dP} dP = \Pi^2 \int_0^{S_c} S^2 \frac{dN}{dS} dS$$

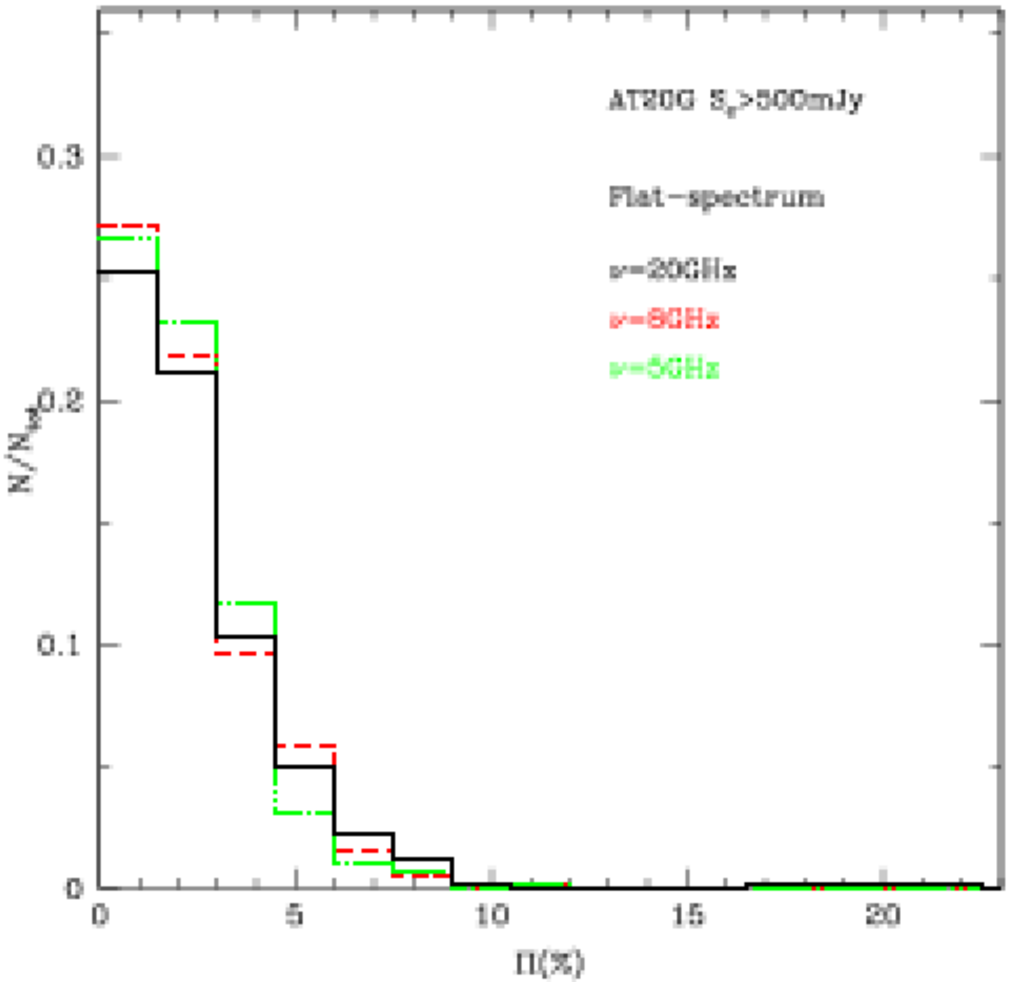
- Spectrum due to all sources: $C_l^{P} = \int_0^{1} \mathcal{P}(\Pi) C_l^{P}(\Pi) d\Pi =< \Pi^2 > C_l^{TT}$

where $\mathcal{P}(\Pi)$ is the probability density function (independent of source flux)

Shot noise

- Formulation which is very convenient, because defined as a function of a cut off flux in total intensity
- Can consider different source populations with different fractional polarisations
- The probability function can be constrained from the observed distributions of fractional polarisation

Fractional polarisation of radio sources



<= Fractional polarisation for flat-spectrum radio sources with S>500 mJy (from Tucci+2012)

See also: Mesa+2002, Tucci +2004, Battye+2011, Farnes +2014

Some constraints but often low-frequency measurements

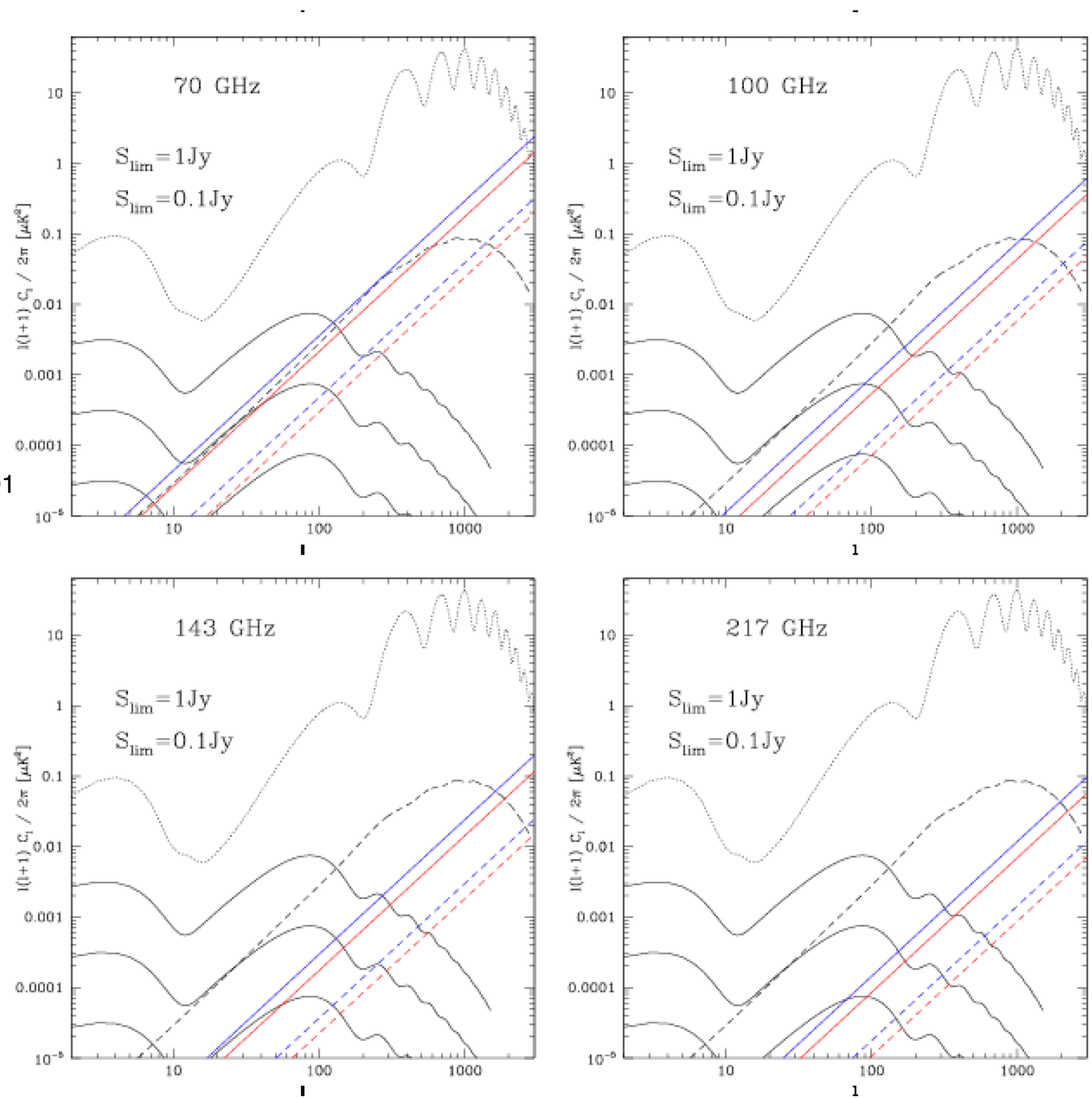
Fractional polarisation of dusty Xgal sources

Little is known on the polarization degree of dusty galaxies

- it is likely to be low because the complex structure of galactic magnetic fields with reversals along the line of sight and the disordered alignment of dust grains reduce the global polarized flux when integrated over the whole galaxy
- the measurements at 850 μm of M82 by Greaves and Holland (2002), gave a global net polarization degree of only 0.4%
- Arp 220 measurements at 850 μm by Seiffert+2006 give a 99% confidence upper limit of 1.54%

Shot noise contamination: radio sources

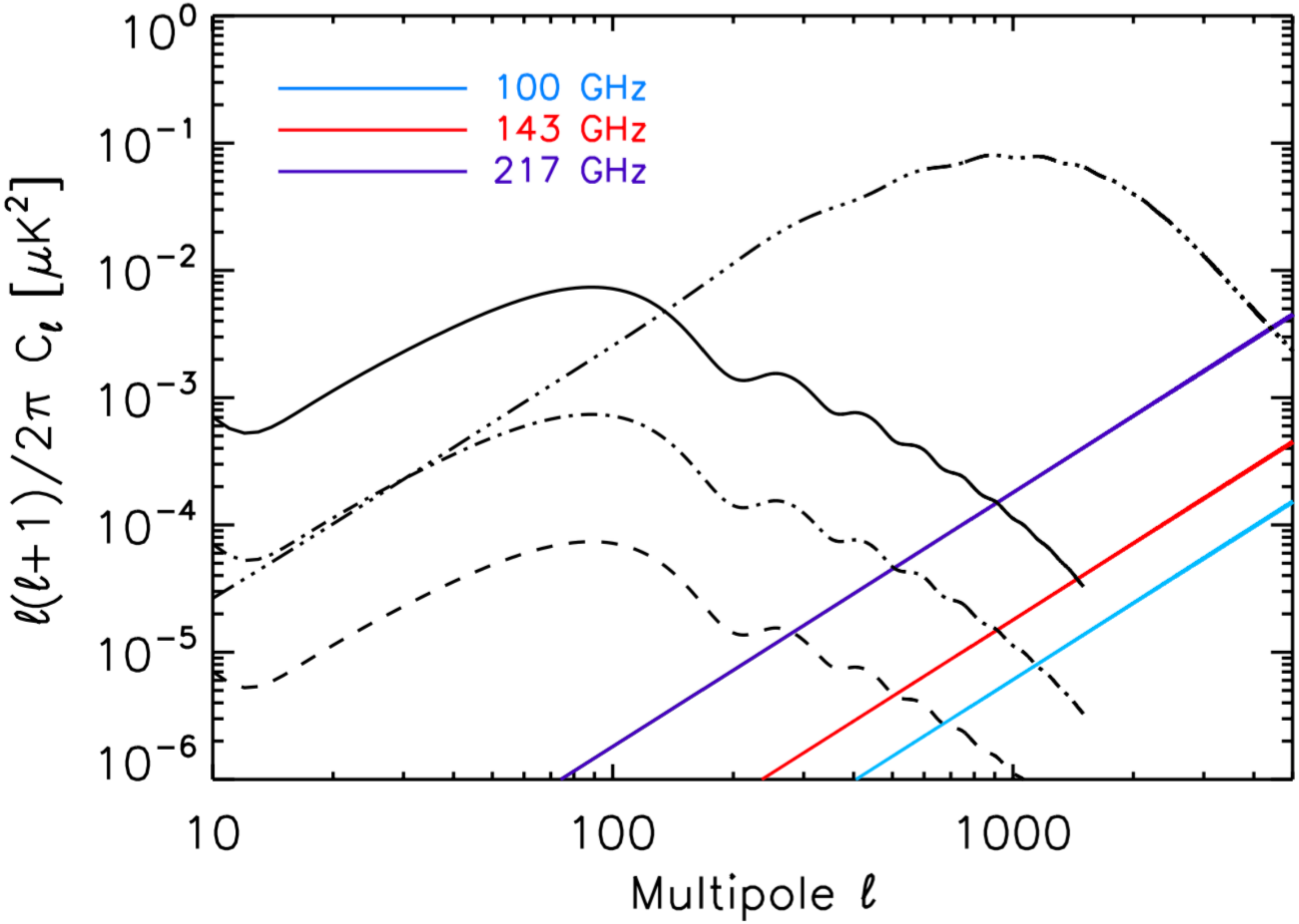
r = 0.1, 0.01 and 0.001



From Tucci & Toffolatti 2012

Shot noise contamination: dusty sources

Estimates for a Planck-like mission
(Scut[1] and frequency bands)
assuming p=0.5%



[1]: But shot noise from dusty galaxies does not depend much on Scut

CIB: let's look at the dark matter power spectrum first…

$$P^{1\mathrm{h}}(k) = \frac{1}{\rho_{\mathrm{M}}^2} \int \mathrm{d}m\, m^2 \frac{\mathrm{d}n}{\mathrm{d}m} \lambda_m^2(k)$$

$$P^{2\mathrm{h}}(k) = \frac{P_{\mathrm{DM}}^{\mathrm{lin}}(k)}{\rho_{\mathrm{M}}^2} \left(\int \mathrm{d}m\, m \frac{\mathrm{d}n}{\mathrm{d}m} \lambda_m(k) b_{\mathrm{h}}(m) \right)^2$$

halo bias

halo mass function

mass density distribution within a halo of mass m

…. and make an analogy

$m \equiv Q = S\,\Pi \cos(2\phi)$

$\langle m^2 \rangle \Rightarrow \langle S^2 \rangle \langle \Pi^2 \rangle \langle \cos^2(2\phi) \rangle = 1/2 \langle S^2 \rangle \langle \Pi^2 \rangle$

$(\langle m \rangle)^2 \Rightarrow (\langle S\Pi\cos(2\phi) \rangle)^2 = 0$

=> Contribution only from the 1-halo

CIB 1-halo anisotropies

$$P_{1\mathrm{h},\nu\nu'}(k,z) = \frac{1}{\bar{j}_\nu \bar{j}_{\nu'}} \int_{M_{\mathrm{min}}}^{\infty} \mathrm{d}M \frac{\mathrm{d}N}{\mathrm{d}M} \times \Big\{ f_\nu^{\mathrm{cen}}(M,z) f_{\nu'}^{\mathrm{sat}}(M,z) u(k,M,z) + f_{\nu'}^{\mathrm{cen}}(M,z) f_\nu^{\mathrm{sat}}(M,z) u(k,M,z) + f_\nu^{\mathrm{sat}}(M,z) f_{\nu'}^{\mathrm{sat}}(M,z) u^2(k,M,z) \Big\}$$

$$f_\nu^{\mathrm{cen}}(M,z) = N_{\mathrm{cen}} \frac{L_{\mathrm{cen},(1+z)\nu}(M_{\mathrm{H}},z)}{4\pi}$$

$$f_\nu^{\mathrm{sat}}(M,z) = \int_{M_{\mathrm{min}}}^{M} \mathrm{d}m \frac{\mathrm{d}n}{\mathrm{d}m}(m_{\mathrm{SH}}, z|M) \times \frac{L_{\mathrm{sat},(1+z)\nu}(m_{\mathrm{SH}},z)}{4\pi},$$

…. need to introduce the polarisation

Conclusions

- Need to reassess the radio shot-noise level - may be a significant contaminant
    - Updated radio source count models
    - Specifications of future CMB experiments (Scut)
- Dusty gal shot noise smaller than radio gal shot noise, even at high frequencies (217 GHz)
    - Because of the very low fractional polarisation
    - But check first estimate
- CIB 1-halo contribution needs to be computed