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On the correlation between the millimeter brightness temperature and the solar magnetic field

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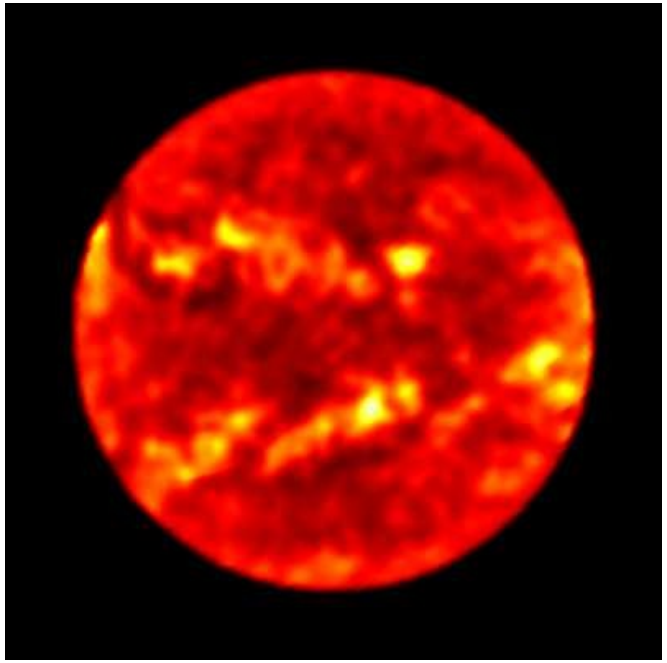
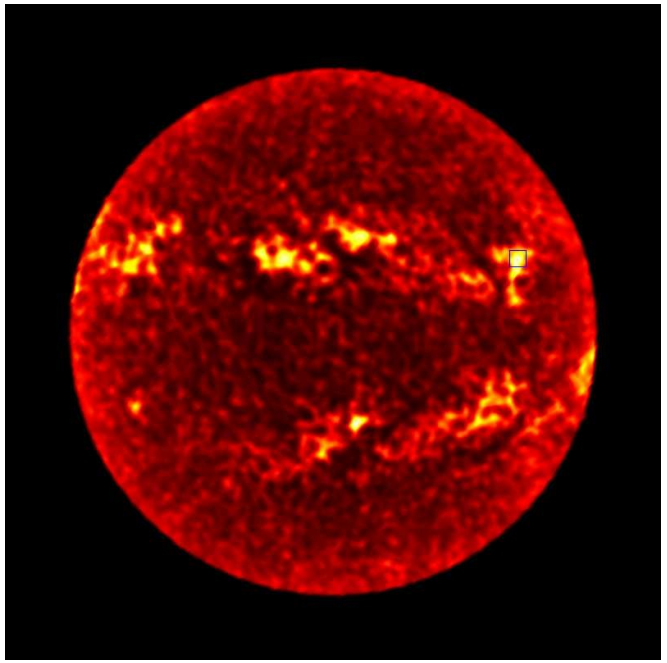
ALMA (single dish) - HMI

ALMA band 3



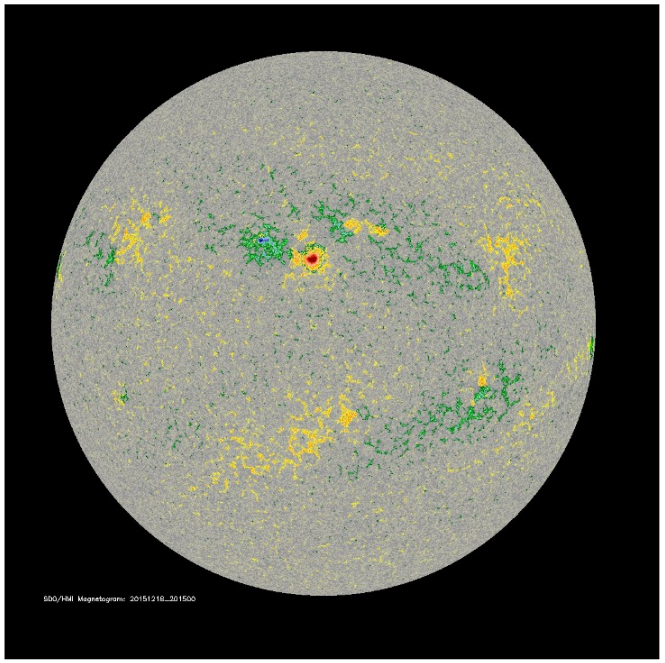
3 mm, 100 GHz, resolution 58”

ALMA band 6



1.2 mm, 239 GHz, resolution 26”

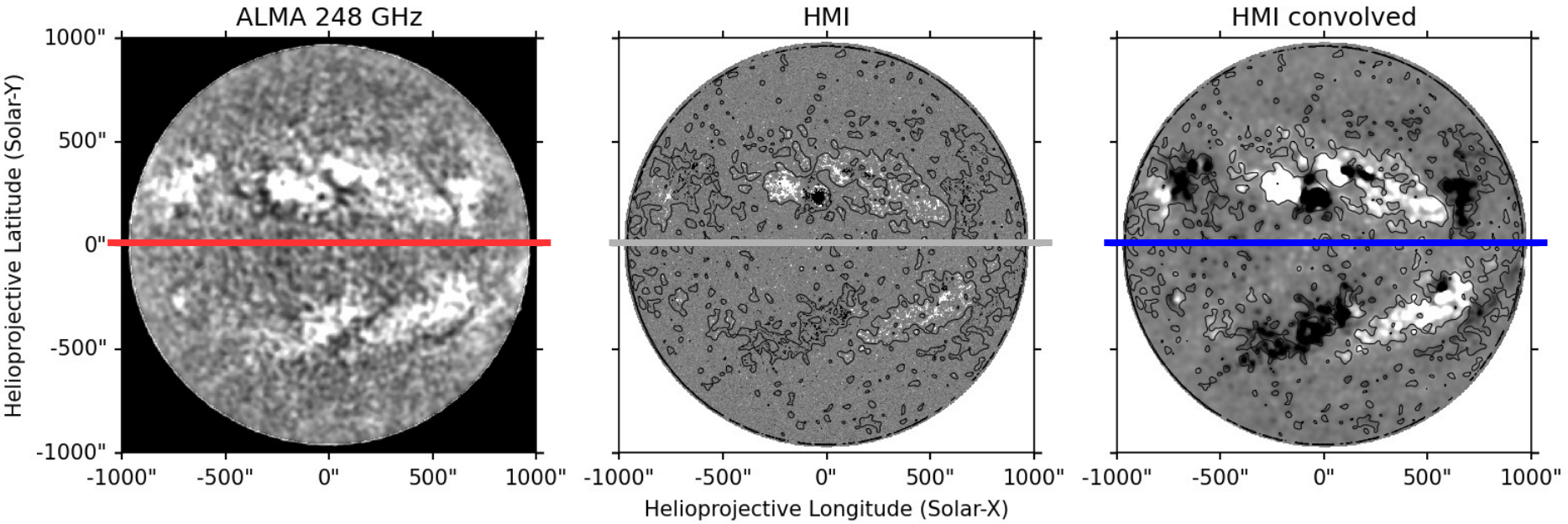
SDO/HMI magnetogram

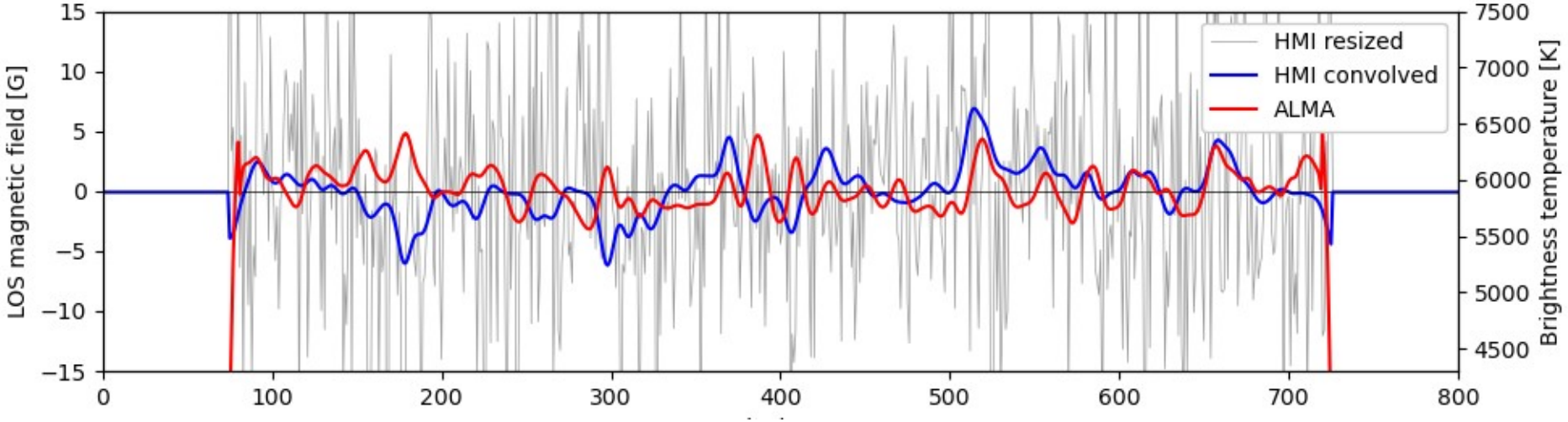


Fe I 617.3 nm, resolution 0.5”

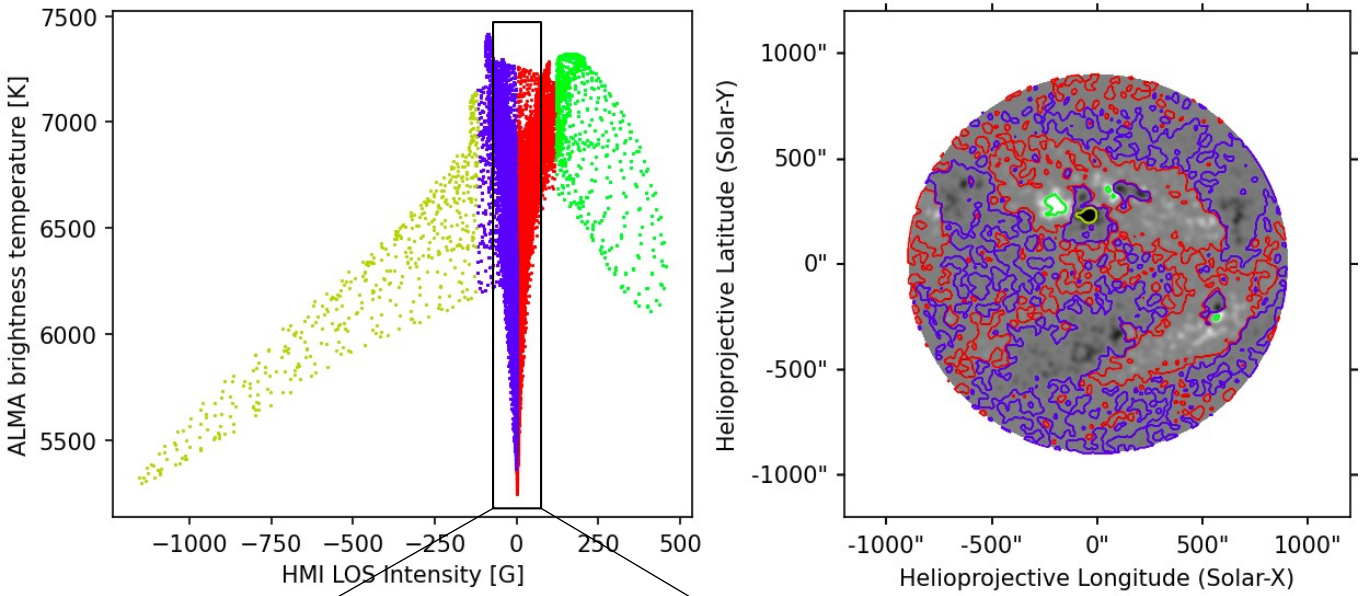
Now also available ALMA band 7 (347 GHz, 0.86 mm), band 5 (198 GHz, 1.5 mm)...

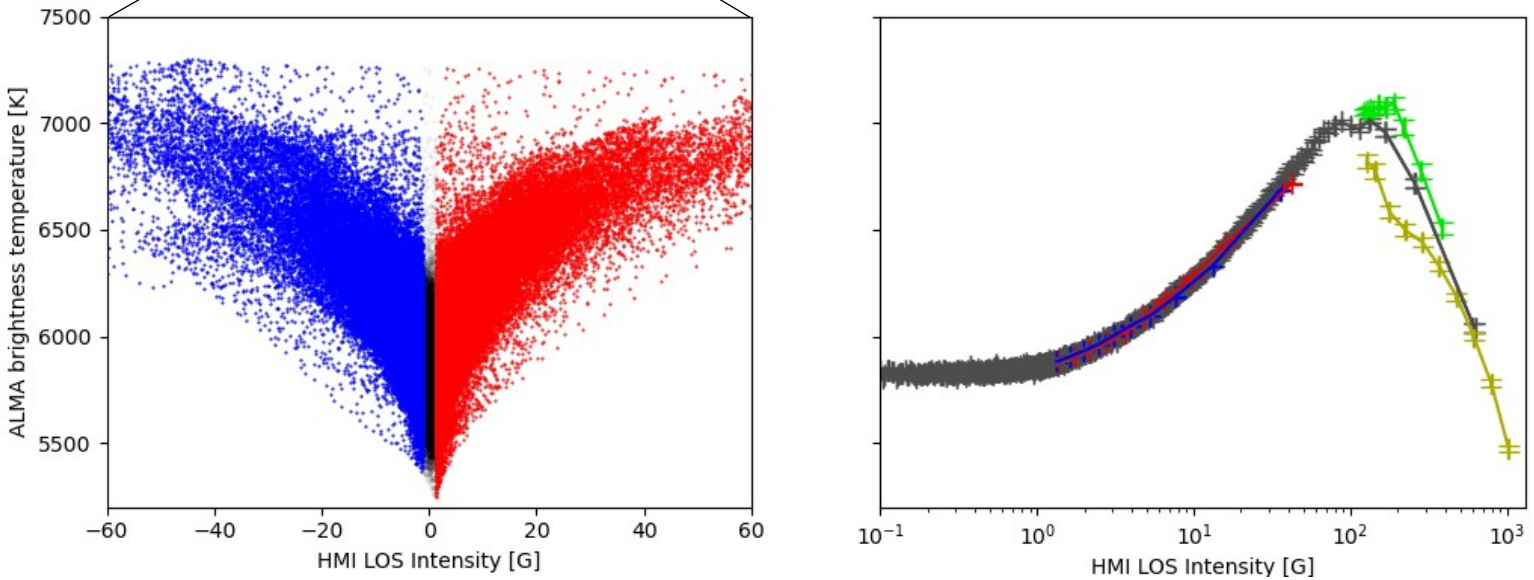
ALMA-HMI correlation



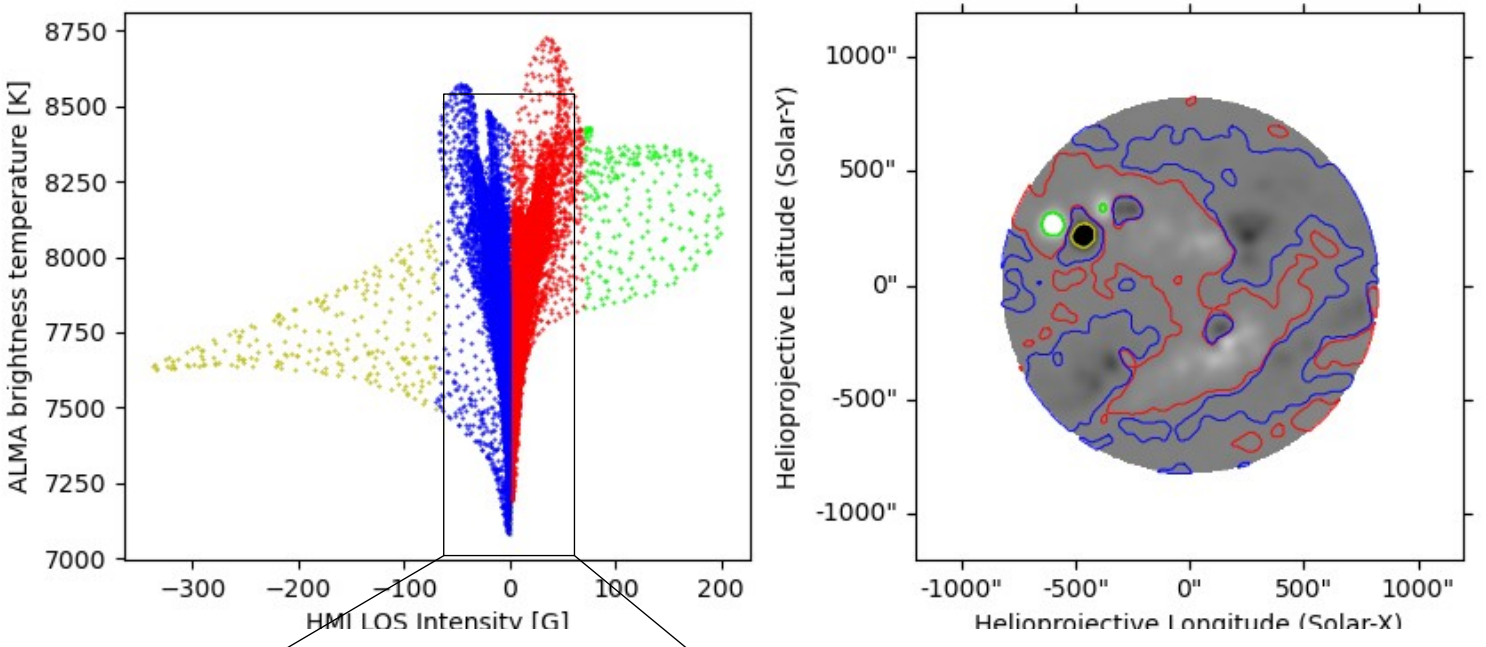


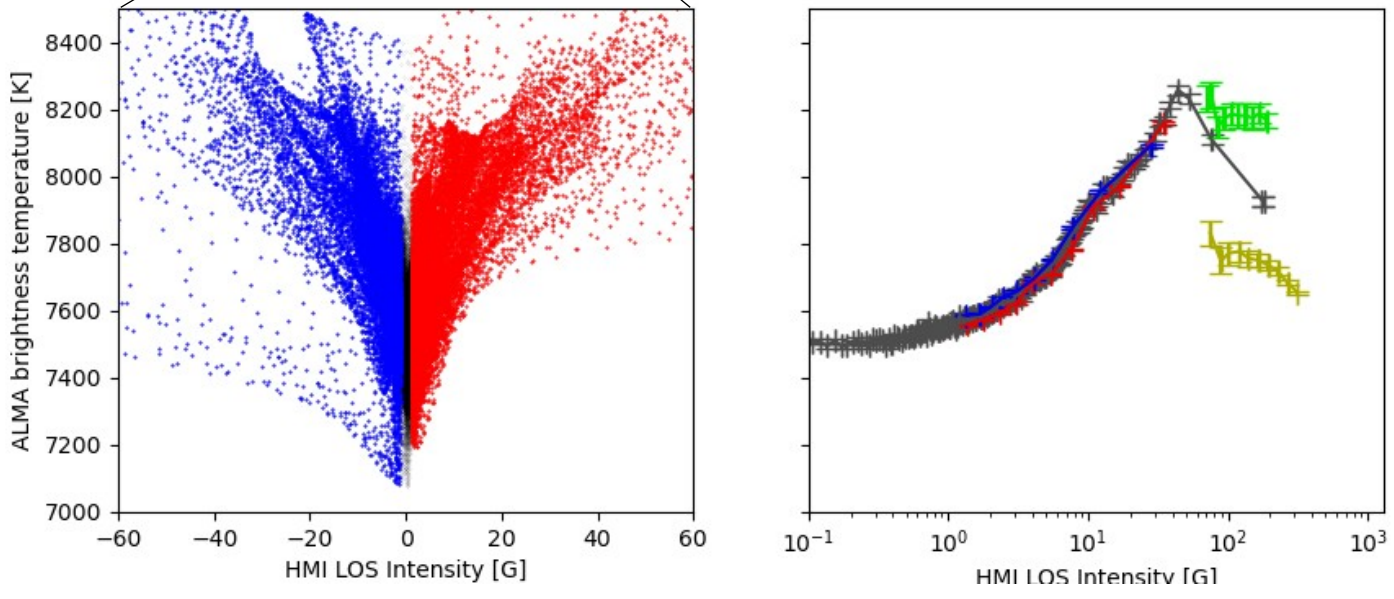
Results - 248 GHz





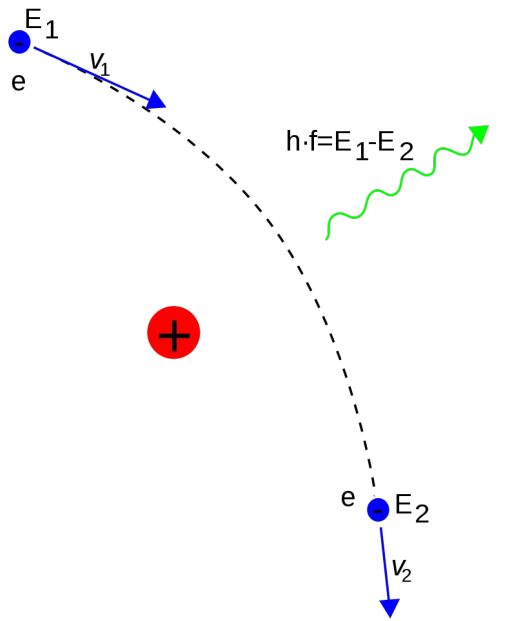
Results - 107 GHz





Sources of radiation

- Plasma emission
- **Bremsstrahlung**
- Gyroresonance
- ...



Electron plasma frequency (CGS):

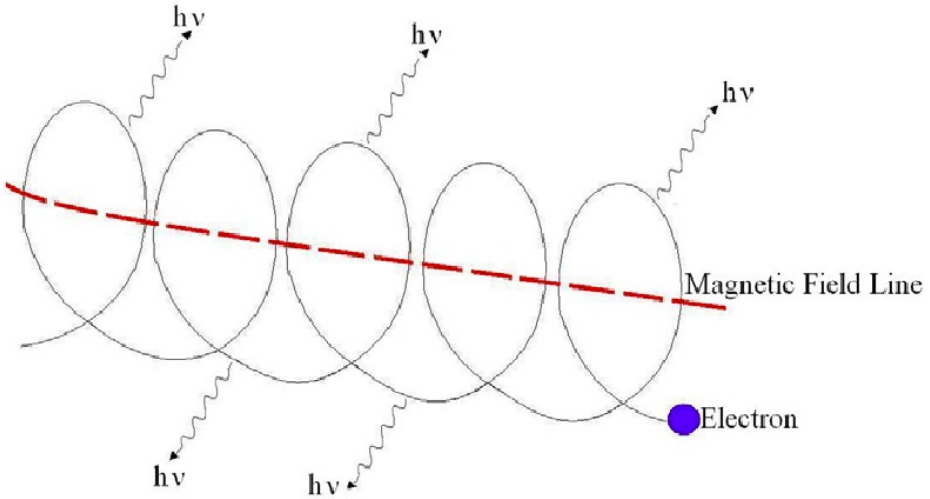
$$f_p = \sqrt{\frac{e^2 n_e}{\pi m_e}} \approx 0.009\sqrt{n_e}\ \mathrm{MHz}$$

Bremsstrahlung (Benz, 2002):

$$\mathrm{d}\tau = \frac{0.01146 \ln \Lambda n_e^2}{(1 - 8.06 \cdot 10^7 n_e/\nu^2)^{1/2}\, \nu^2 T_e^{3/2}} \mathrm{d}s$$

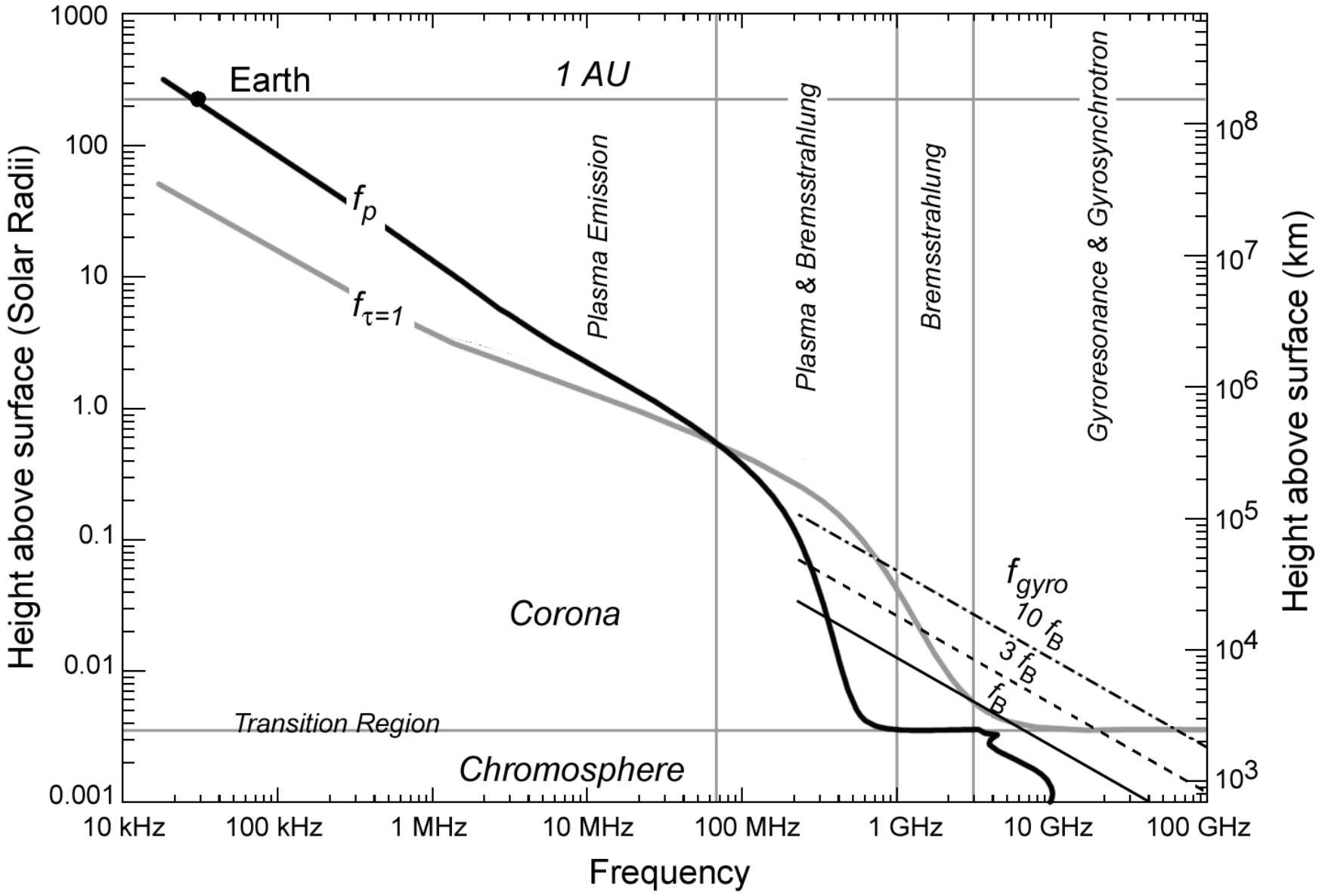
Electron gyrofrequency (CGS):

$$f_B = \frac{eB}{2\pi m_e c} \approx 2.8B\ \mathrm{MHz}$$



At 248 GHz at 3rd harmonic ~30 kG needed!

Sources of radiation



Courtesy: Dale E. Gary, NJIT

Conclusions

ALMA 248 GHz
- no correlation for QS regions
- anticorrelation for sunspots
- correlation for network and ARs
- at ~1 G (no correlation -> correlation), ~120 G (correlation -> anticorrelation)

ALMA 107 GHz
- no correlation for QS regions
- weak anticorrelation for sunspots
- correlation for network and ARs
- at ~1 G (no correlation -> correlation), ~70 G (correlation -> anticorrelation)

Radiation mechanism
- Most probable thermal bremsstrahlung, convection inhibited by mag. field in SS
- field strengths too weak for the gyroresonance to contribute significantly

Next to address
- use more images
- use HMI full vector field (what about center-to-limb of ALMA?)
- interferometric ALMA data
- comparison with simulations

Acknowledgements

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AIA/HMI images are courtesy of NASA/SDO and the AIA, EVE, and HMI science teams.