Extragalactic Astronomy II

Lecture 6

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Emission lines from AGN or from non-AGN source?

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Massive stars have a clear cut-off in their ionizing spectrum, at the Lyman-limit of helium (corresponding to 228 Angstrom), whereas the non- thermal radiation from AGNs extends to much higher photon energies. As a consequence, the ratio of collisionally excited lines to that of lines which are produced in the course of recombination is larger in the case of an AGN–like ionizing radiation field.

Strength of an emission line

How does one measure the strength of an emission/absorption line?

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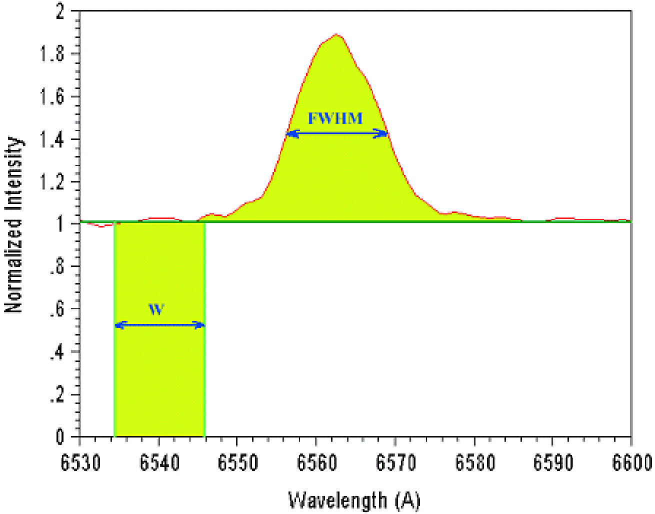
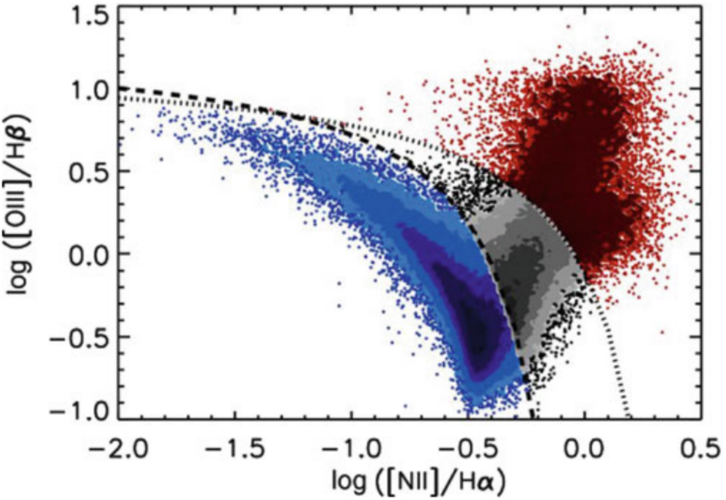
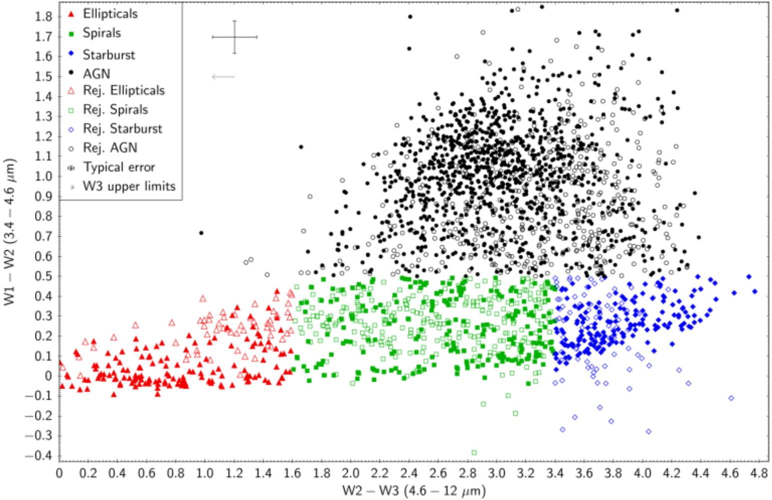


The BPT diagram with 240,000 galaxies from SDSS



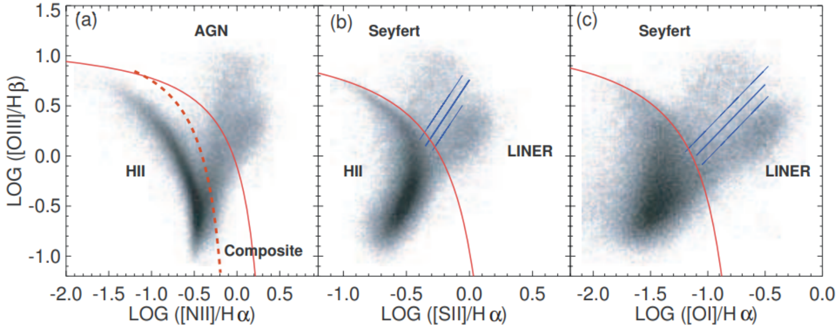
Trouille et al. (2011), Baldwin, Phillips & Terlevich (1981) Is is possible to separate AGN and star-forming galaxies without a spectrum?

WISE colors



Mingo et al. (2016) W1, W2, W3, W4 at 3.4, 4.6, 12 and 22 microns respectively.

Different lines for BPT diagrams

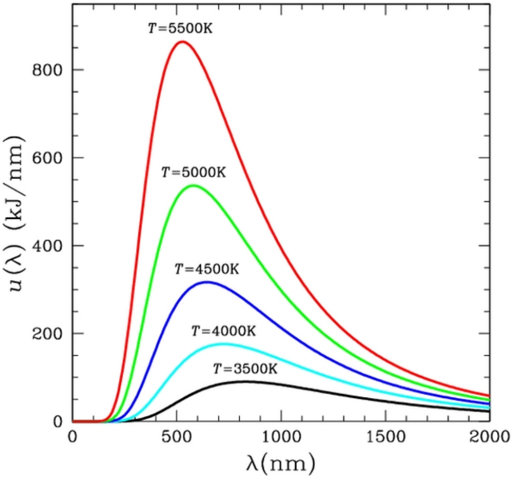


Groves & Kewley (2008)

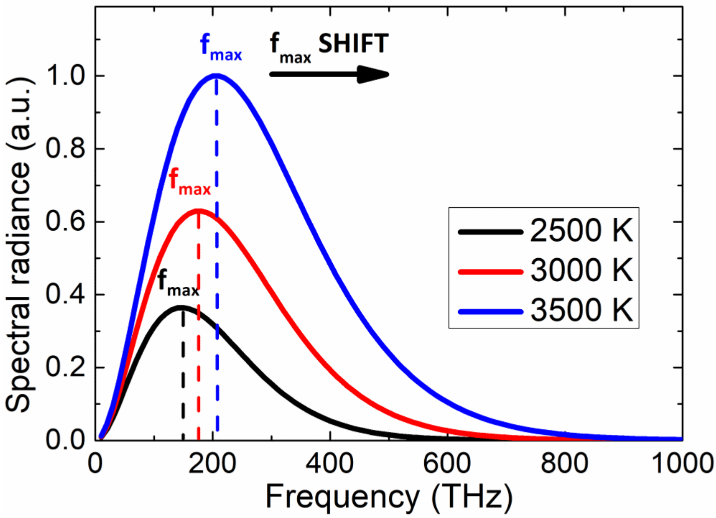
What have we covered so far?

are aspects of the phenomenology of Quasars (radio-loud and radio-quiet, OVVs, blazars, optically quasars), Seyfert 1 and 2. Next we move to the study of radio emission from AGN.
Syllabus:
Phenomenology of AGNs (Seyferts, Quasars, Radio Galaxies, LINERS, BL Lacs) with a survey of continuum, emission and absorption features of spectra - Black hole and accretion disc models for AGNs - Emission line regions (BLR, NLR) - Physics of jets and hot spots.

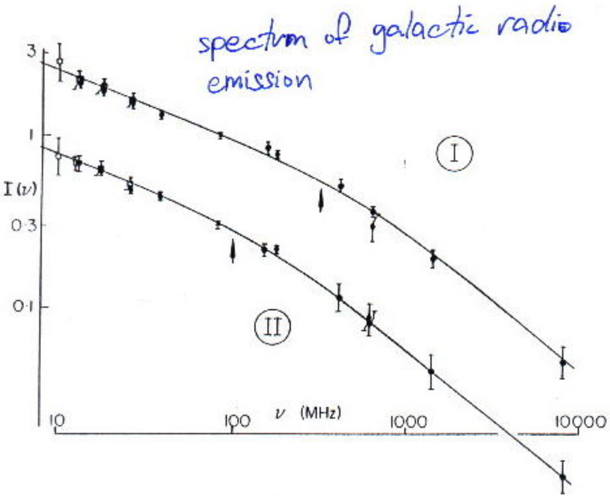
Typical stellar spectrum is blackbody!



Black body spectrum versus frequency



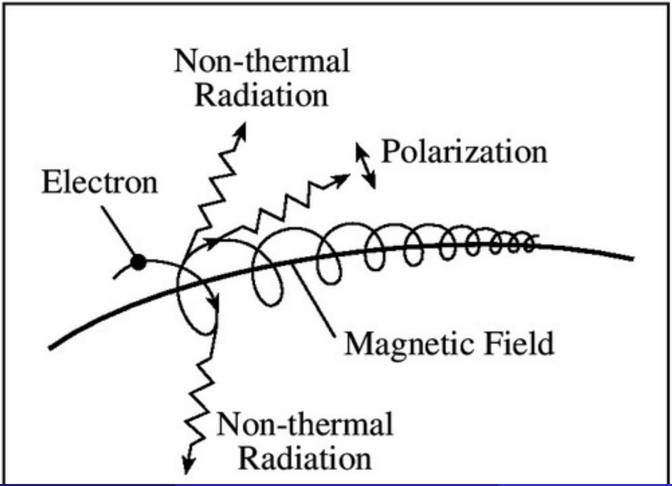
Typical radio spectrum



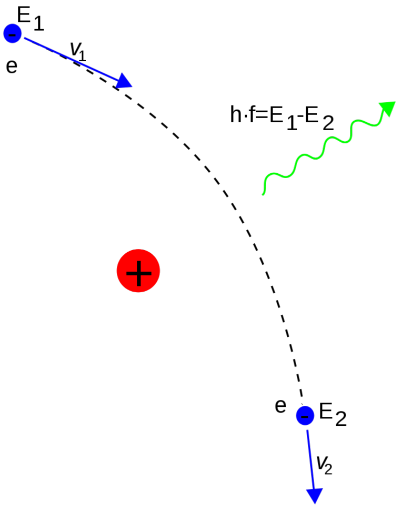
Why can't this possibly be a blackbody?

Dominant physical mechanism for *continuum* radio emission

radio emission due to synchrotron emission by **relativistic charged particles** (electrons) in a **magnetic field.**



Thermal Bremsstrahlung - Free-Free radiation



Characteristic frequency of synchrotron radiation

$$\nu_c = \frac{3\gamma^2 eB}{4\pi m_e c} \sim 4.2 \times 10^6 \gamma^2 (B/1G)\ \mathrm{Hz}$$

Assuming typical IGM magnetic field strengths, what must be the γ for radiation to be emitted at a characteristic frequency of 1 GHz?

Synchrotron Power radiated by an electron

$$P = \frac{4}{9}\frac{e^4 B^2 \gamma^2}{m_e^2 c^3}$$

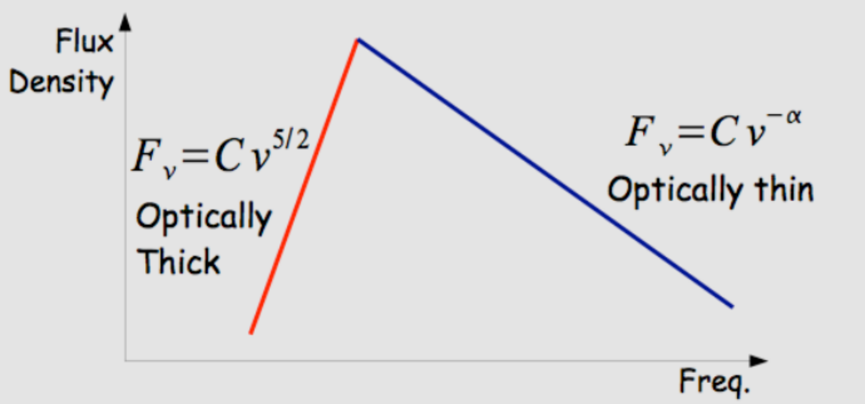
For more detailed discussion on synchrotron processes, see *Radiative Processes in Astrophysics* by Rybicki and Lightman.

Synchrotron self absorption

If the intensity of synchrotron radiation within a source becomes sufficiently high, then re-absorption of the radiation by the synchrotron electron themselves becomes important. This re-absorption of radiation is termed as 'synchrotron self absorption'. Synchrotron self-absorption will drastically modify the spectrum of the source at low frequencies.

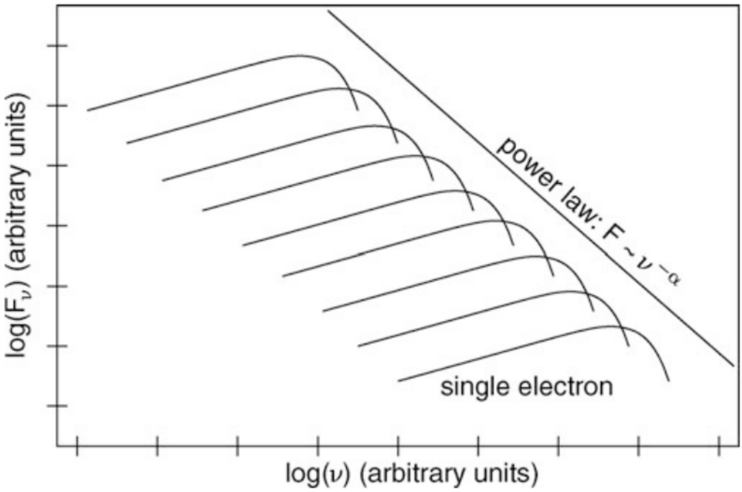
At high densities and at low enough frequencies, synchrotron self absorption becomes important, and part of the radiation absorbed by the relativistic electrons along the propagation path.

Synchrotron spectrum



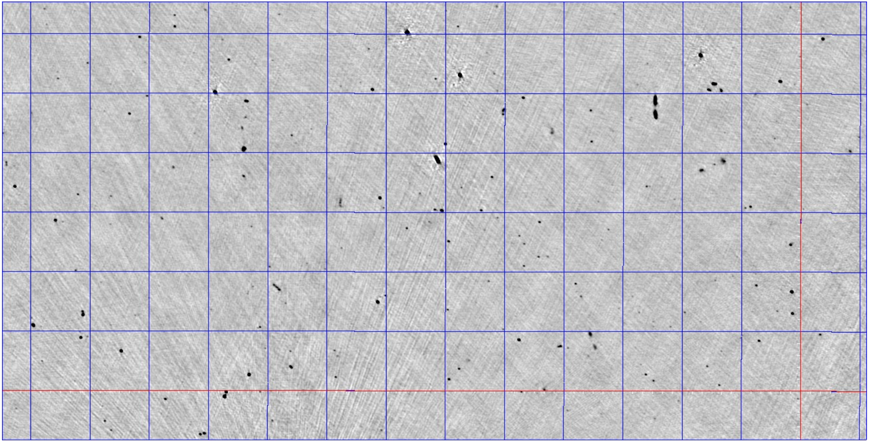
Note: Both axes are plotted on a log scale.

Synchrotron spectrum



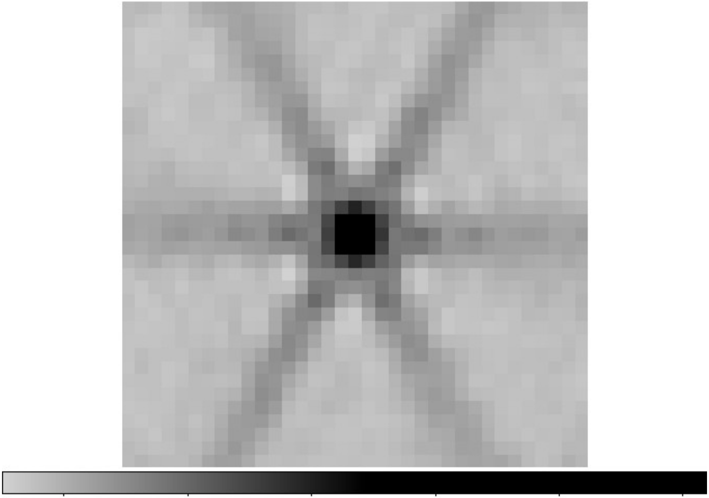
If the electron energy distribution is a power-law $N(E)dE = N_0 E^{-s} dE$, th resultant synchrotron radiation is also a power law.

A deep GMRT Radio image



GMRT proposal 20_006, PI: Wadadekar, rms 150 μJy

Even deep radio images are quite sparse



Median stack of FIRST survey at 2e5 quasar positions

Main morphological features of a radio galaxy