Telecommunication Systems

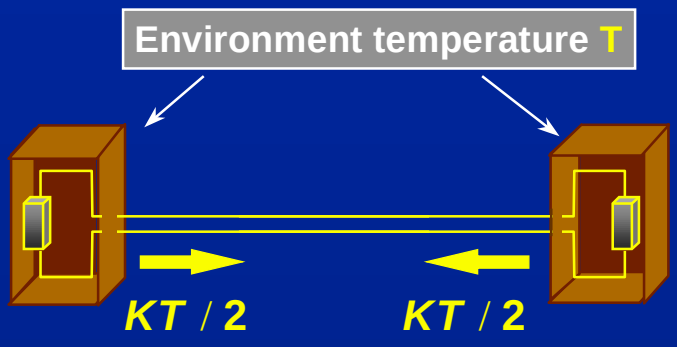
Module 0
Antennas and Propagation

0.5 - Antenna noise

In transmission systems that utilize propagation of electromagnetic waves, in addition to the sources of noise in the electronic apparatus, we must also consider the noise contributions introduced at the antenna itself.

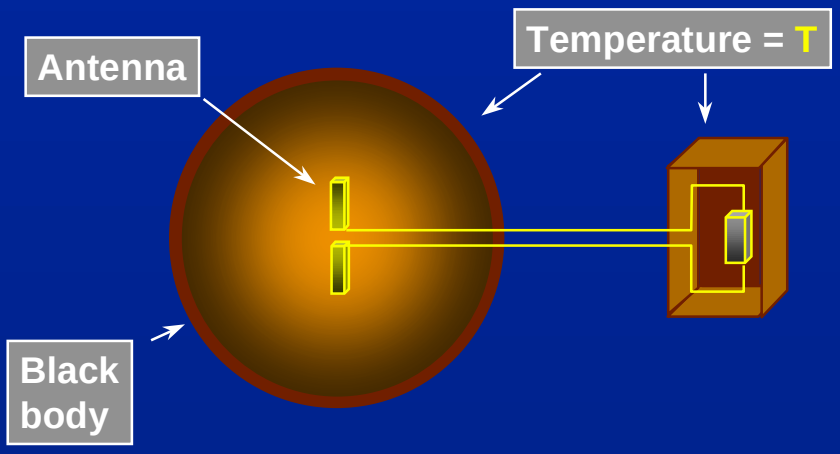
This noise contribution is measured as the so called antenna noise temperature

In the case of thermal noise generated by resistors:

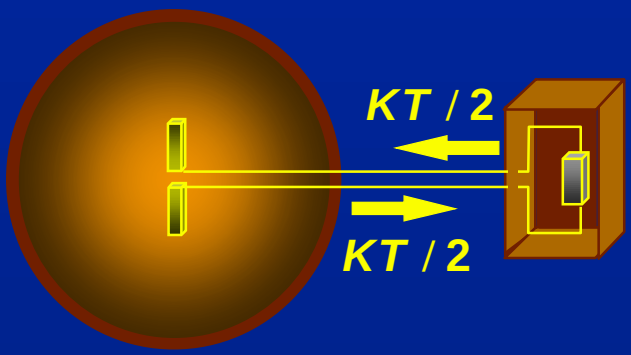


The noise spectral densities must be equal by the 2-nd law of Thermodynamics

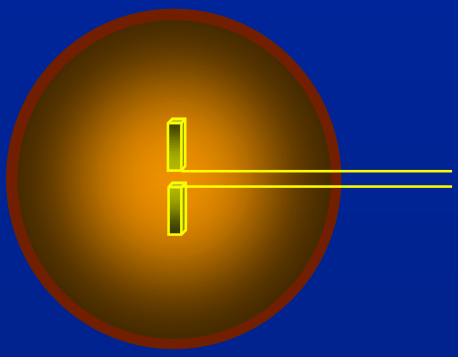
Substituting one of the two resistors by an antenna enclosed in a black body at temperature T



In order to obey the thermodynamic equilibrium, it is necessary that the antenna generate noise with power spectral density equal to $KT / 2$



Under such a condition, the antenna behaves like a resistor maintained at a physical temperature T



Power spectral density

$= KT / 2$

We can now define the

Antenna noise temperature

as the temperature of a black body that, in reference to the preceding conceptual experiment, generates the same noise spectral density actually observed

This definition, allows us to substitute the antenna, in connection with its noise behavior, with a resistor at physical temperature Ta

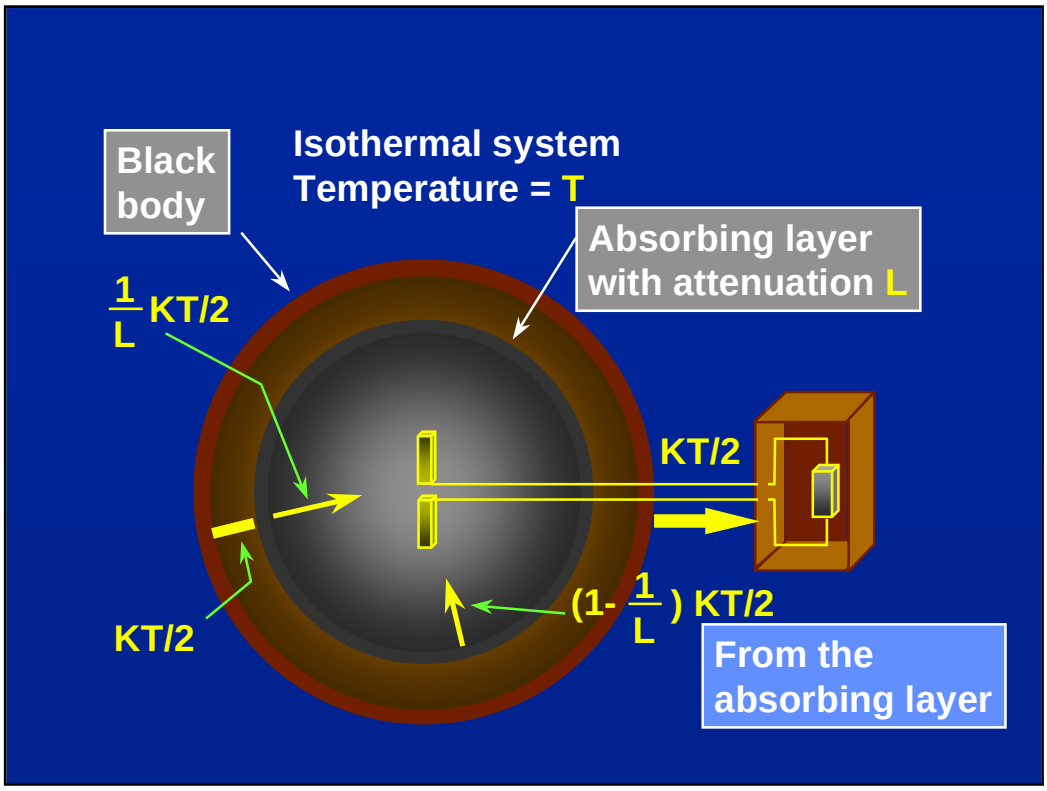
Principal causes of the antenna noise:

- Absorption noise
- Galactic noise
- Irradiation noise

ABSORPTION Noise

This noise is generated by gaseous components in the atmosphere that are able to attenuate an EM field by molecular absorption

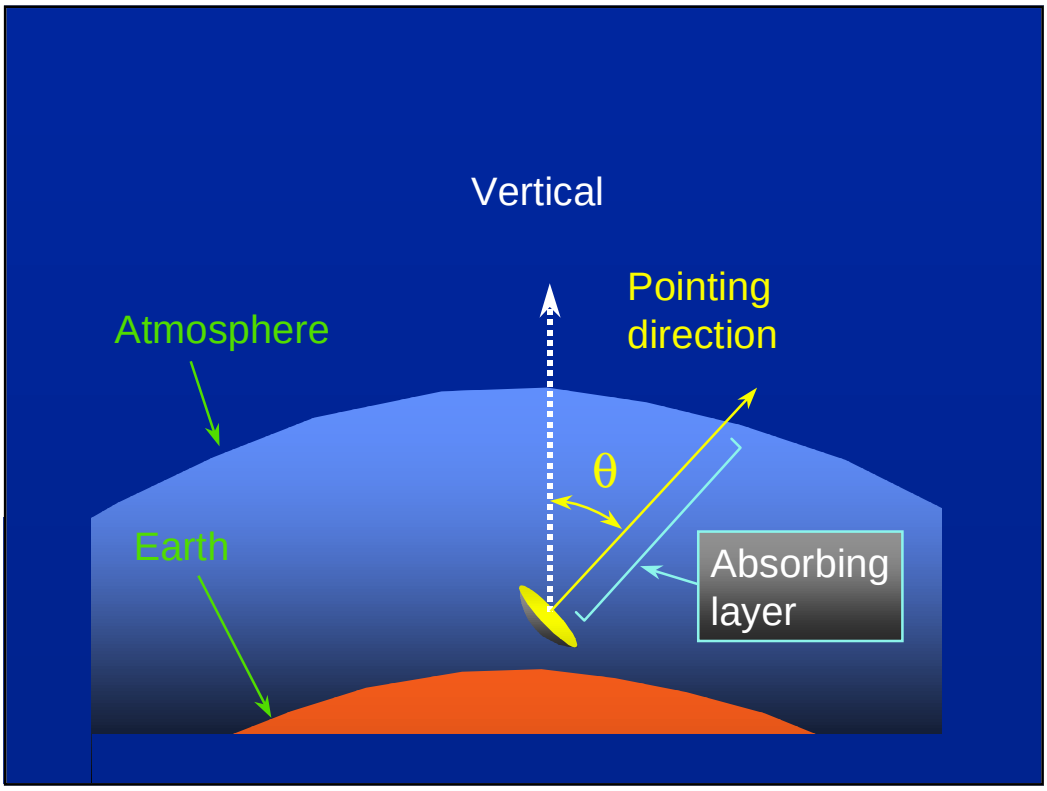
In order to verify that an absorbing layer is able to generate noise, we can conduct a conceptual experiment



We observe that the absorbing layer generates a **contribution to noise** whose value depends on:

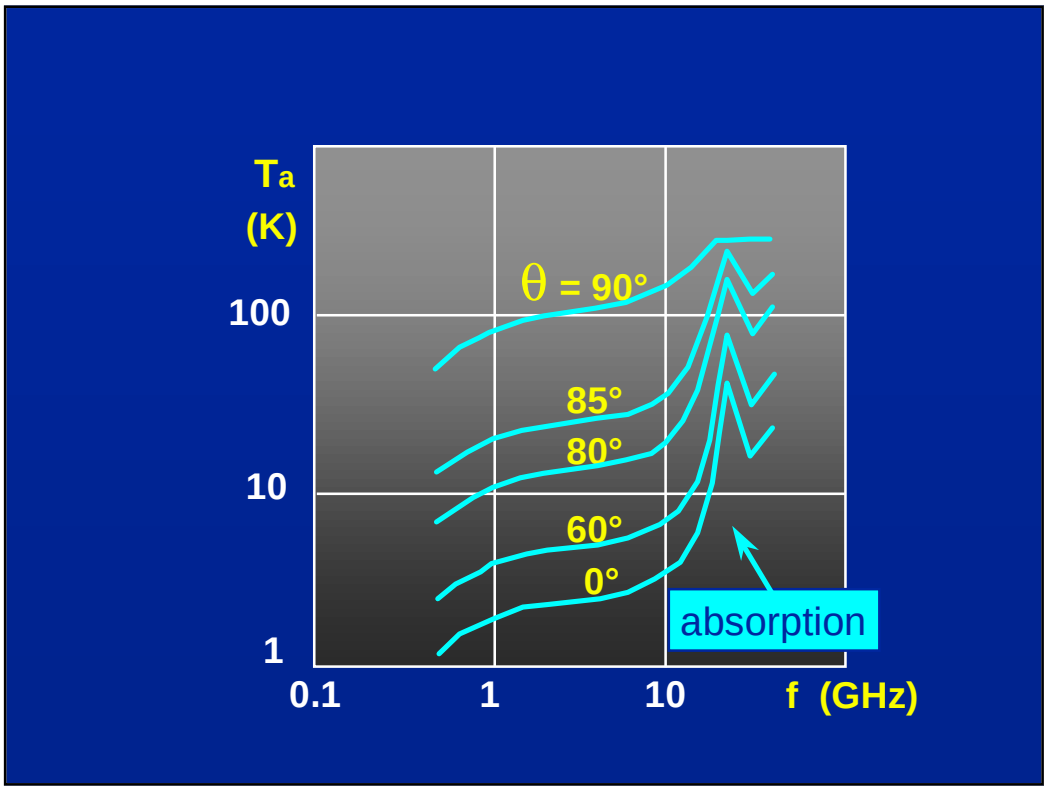
- ⋆ attenuation **L** of the layer
- ⋆ its **temperature**

In the case of an antenna on the surface of the earth and pointing towards sky, the absorbing layer is the **atmosphere**



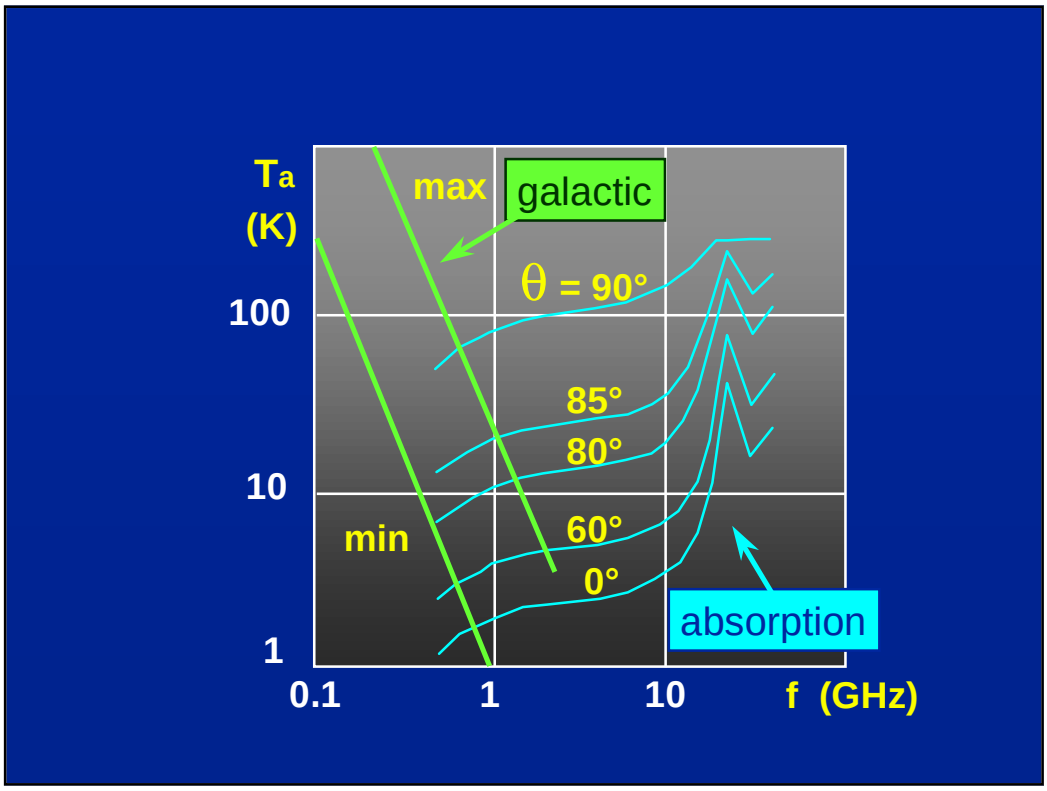
The attenuation itself on the other hand depends on:

- ★ **Temperature distribution**
- ★ **Composition of the atmosphere**
- ★ **Pointing angle of antenna** θ
- ★ **Frequency**



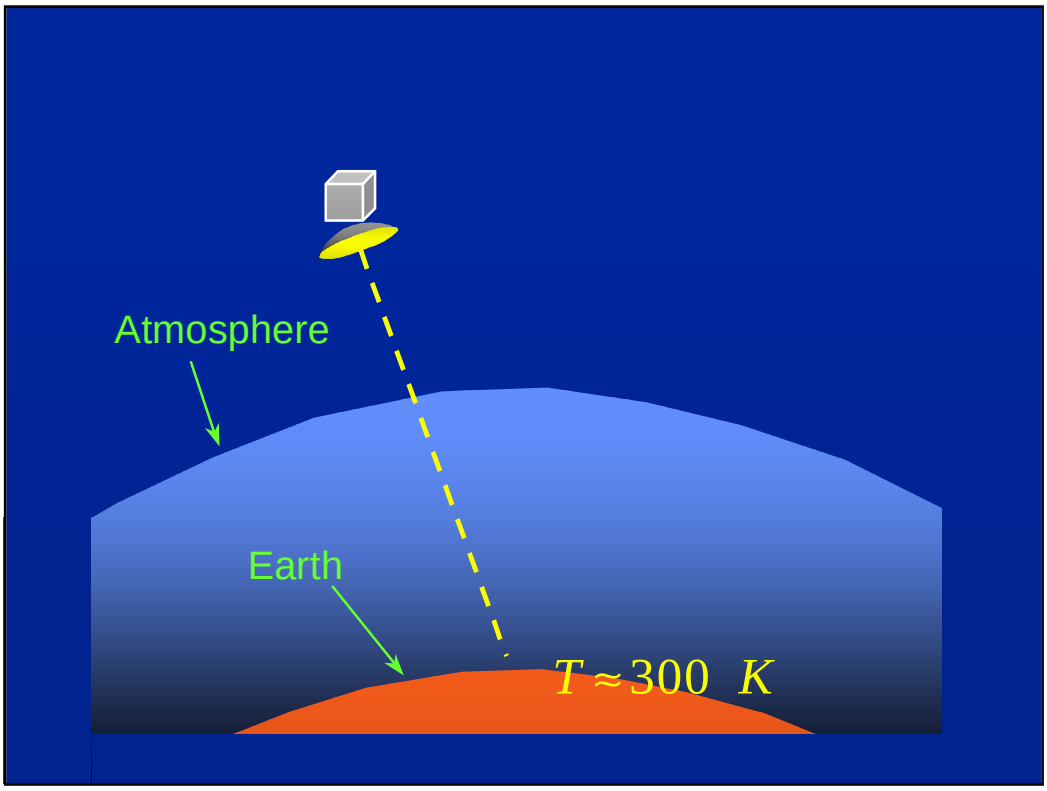
GALACTIC Noise

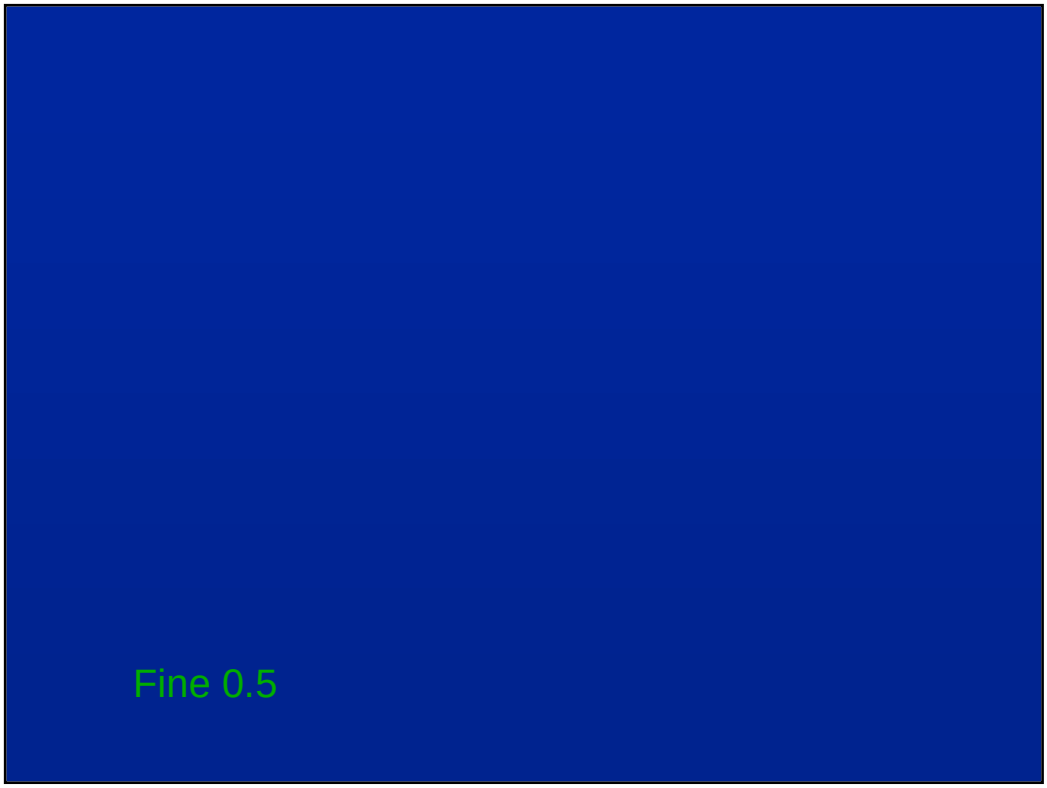
- Has its origin in deep space
- Depends on the pointing direction of the antenna
- Depends on the frequency in a manner approximately proportional to $f^{-2.5}$



IRRADIATION Noise

- Important for antennas pointing towards earth
- In particular, the on-board antennas of space craft
- Earth behaves approximately as a black body at a temperature of 300 K
- The antenna temperature in this case is approximately 300 K


Atmosphere
Earth
$T \approx 300\ K$


Fine 0.5