A Glossary to some General (Astro)Physical terms

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Abstract

This is a simple document which will hopefullyeventually be a pretty complete list/glossary of various (astro)Physical terms and 'what they mean'. There will be some overlap here with my other Research Notes, e.g. the Emission Line document...

A

Advection

Advection is the transport of a substance by bulk motion, and more specifically, the transfer of heat or matter by the flow of a fluid, especially horizontally in the/an atmosphere or the sea.

Advection Dominated Accretion Flows

The Eddington accretion rate is the accretion rate for which the black hole radiates at the Eddington luminosity:

$$\dot{M}_{\rm Edd} = L_{\rm Edd}/\epsilon c^2. \tag{1}$$

It is generally thought that when the accretion rate is $\sim 0.01 - 11\dot{M}_{\rm Edd}$ thin disk accretion is a reasonable approximation. With a high accretion rate, the gas density is high, so the gas is able to radiate efficiently and stay geometrically thin.

However, if the gas density is low, the gas may be unable to radiate energy at a rate that balances viscous heating. In this case, the heat generated by viscosity will be "advected" inwards with the flow instead of being radiated. Crucially, the disk becomes hot, hence geometrically thick (though perhaps optically thin), hence low density, and radiatively inefficient. Such "Advection Dominated Accretion Flows" (ADAFs) were studied by Lightman & Eardley, Rees, and others in the 1970s. They were revived in the 1990s by the work of Narayan & Yi and others.

At superEddington accretion rates, in which the large optical depth of the inflowing gas traps most of the radiation and carries it inward, or advects it, into the central black hole. This solution is referred to as an optically thick advectiondominated accretion flow (optically thick ADAF).

B

Baldwin Effect

Baldwin (1977) was the first to discover an anti- correlation between the equivalent width (EW) of the C IVλ1549 emission line and its nearby continuum luminosity in the QSO rest frame (i.e. the Baldwin effect; see a review by Shields 2007).

Explainations include:

- One promising interpretation is the softening of the spectral energy distribution (SED) for increasing luminosity, which lowers the ion (e.g. Netzer et al. 1992; Dietrich et al. 2002).

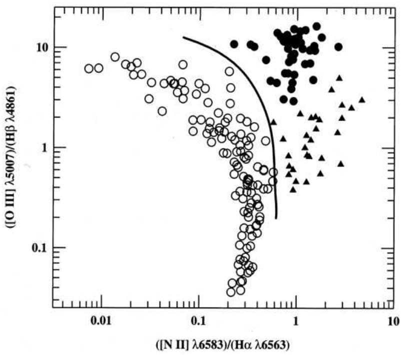

Figure 1:

- For the PalomarGreen (PG) sample of QSOs, Baskin & Laor (2004) have found a strong correlation between the C IVEW and $L_{\mathrm{Bol}}/LEdd$, and they have suggested that LBol /LEdd is the primary physical parameter driving the Baldwin effect.

BPT diagram

Straight from:: Level 5 BPT essay::

"Baldwin, Phillips & Terlevich" (BPT) diagrams demonstrate how LINERs can be distinguished from normal H II regions and normal AGNs (Seyferts and QSOs) on the basis of their [O III] λ5007 / Hβ, [N II] λ6583 / Hα, and [S II] $\lambda\lambda$6716, 6731 / Hα flux ratios. Here it is seen that the Seyfert 2s have high values of each ratio. H II regions define a locus of lower values which does not overlap with the region of parameter space occupied by the Seyferts. The LINERs can be distinguished from the Seyfert 2s by their low values of [O III] λ5007 / Hβ relative to [N II] λ6583 / Hα, and from the H II regions by their larger values of [N II] λ6583 / Hα.

[O III]/[O II] is sensitive to ionization parameter (how ionized is the gas). [O I]/ H α is sensitive to hardness of the radiation field.

Bondi Accretion

BA is spherical accretion onto a compact object traveling through the interstellar medium. It is generally used in the context of neutron star and black hole accretion. To achieve an approximate form of the Bondi accretion rate, accretion is assumed to occur at a rate

$$\dot{M} \simeq \pi R^2 \rho v \tag{2}$$

where ρ is the ambient density, v is either the velocity of the object or the sound speed c_s in the surrounding medium if the object's velocity is lower than the sound speed, and the Bondi radius R provides an effective area. The effective radius is acquired by equating the object's escape velocity and the relevant speed, i.e.

$$\sqrt{\frac{2GM}{R}} \simeq c_s, \tag{3}$$

or

$$R \simeq \frac{2GM}{c_s^2}. \tag{4}$$

The accretion rate therefore becomes

$$\dot{M} \simeq \frac{\pi \rho G^2 M^2}{c_s^3}. \tag{5}$$

These are only scaling relations rather than rigorous definitions. A more complete solution can be found in Bondi's original work and two other papers.

AGN Accrete from the ISM, Via Bondi accretion:

$$\dot{M} \simeq (1.4 \times 10^{11} \mathrm{g/s}) \left(\frac{\mathrm{M}}{\mathrm{M}_\Theta}\right) \left(\frac{\rho}{10^{-24}\ \mathrm{g/cm^3}}\right) \left(\frac{\mathrm{c_s}}{10\mathrm{km/s}}\right)^{-3} \tag{6}$$

M_Θ should be $M_\odot$??!!

Bremsstrahlung

Bremsstrahlung (German for braking radiation), a.k.a.'Free-free' emission arises when a charged particle (i.e., an electron) is accelerated though the Coulomb interaction with another charged particle (i.e., an ion of charge Ze). Effectively what happens is that the two charges make up an electric dipole which, due to the motion of the charges, is time variable. A variable dipole is basically an antenna, and emits electromagnetic waves. The energy in these EM waves (photons) emitted is lost to the electron, which therefore loses (kinetic) energy (the electron is braking).

Bound-Bound Transition

A change to the energy of an electron within an atom (or more rarely within a molecule) in which the electron remains attached (bound) to the atom both before and after the change. When the energy is increased, a photon is absorbed; when the energy is reduced, a photon is emitted. Boundbound transitions produce the emission and absorption lines found in spectra.

$$h\nu = \chi_u - \chi_l \tag{7}$$

Bound-Bound Transition

electron moves between bound and unbound states. Bound-unbound is ionization. Unbound-bound is recombination.

$$h\nu = \chi_{\mathrm{ion}} - \chi_n + \frac{1}{2} m u^2 \tag{8}$$

C

Compton scattering

Compton scattering (discovered by Arthur Holly Compton) is the inelastic scattering of a photon by a charged particle, usually an electron. It results in **a decrease in energy (increase in wavelength) of the photon** (which may be an X-ray or gamma ray photon), called the Compton effect. Part of the energy of the photon is transferred to the recoiling electron.

Comption Thick

Objects, or systems, that have column densities exceeding $N_{\mathrm{H}} \simeq 1.5 \times 10^{24}$ cm^{-2}, the value corresponding to unity optical depth for Compton scattering.

Straight from: Comastri, astro-ph/0403693:: The spectrum of the hard X-ray background records the history of accretion processes integrated over the cosmic time. Several pieces of observational and theoretical evidence indicate that a significant fraction of the energy density is obscured by large columns of gas and dust. The absorbing matter is often very thick, **with column densities exceeding $N_{\mathrm{H}} \simeq 1.5 \times 10^{24}$ cm^{-2}, the value corresponding to unity optical depth for Compton**

scattering. These sources are called "Compton thick" and appear to be very numerous, at least in the nearby universe. Although Compton thick Active Galactic Nuclei (AGN) are thought to provide an important contribution to the overall cosmic energy budget, their space density and cosmological evolution are poorly known. The properties of Compton thick AGN are reviewed here, with particular emphasis on their contributions to the extragalactic background light in the hard X-ray and infrared bands.

Comption Thin

Objects, or systems, that have column densities in the range $N_{\rm H} \simeq \times 10^{22} - 10^{24}$ cm^{-2}. These can still be (kinda confusingly known as) "obscured systems".

Continuum radiation

www.astro.yale.edu/vdbosch/astro320_summary27.pdf. Continuum radiation is any radiation that forms a continuous spectrum and is not restricted to a narrow frequency range. One can consider five continuum emission mechanisms:

- Thermal (Black Body) Radiation
- Bremsstrahlung (free-free emission)
- Recombination (free-bound emission)
- Two-Photon emission
- Synchrotron emission

Covering Factor

The fraction of sight-lines to the AGN centre obscured by dust (e.g., Roseboom et al., 2013).

D

Duty cycle

The fraction of the time that an AGN/QSO is active.

E

Entropy

Extinction

Extinction is the absorption and scattering of electromagnetic radiation by dust and gas between an emitting astronomical object and the observer.

F

Free-free transitions

Free electron gains energy by absorbing a photon as it passes an ion, or loses energy by emitting a photon. This emission process is called Bremsstrahlung (braking).

$$h\nu = \frac{1}{2}mu_2^2 - \frac{1}{2}mu_1^2 \tag{9}$$

H

Hard X-rays

See:: X-rays, Hard.

I

Instabilites

Papaloizou-Pringle instability
Taylor-Couette Flow

Inverse Compton scattering

Inverse Compton scattering involves the scattering of low energy photons to high energies by ultra-relativistic electrons **so that the photons gain and the electrons lose energy**. The process is called inverse because the electrons lose energy rather than the photons.

e.g., in X-ray astronomy, the accretion disc surrounding a black hole is presumed to produce a thermal spectrum. The lower energy photons produced from this spectrum are scattered to higher energies by relativistic electrons in the surrounding corona. This is surmised to cause the power law component in the X-ray spectra (0.2-10 keV) of accreting black holes (Wikipedia link).

Also, e.g., CMB photons are scattered to higher energies by the electrons in this gas, resulting in the Sunyaev-Zel'dovich effect. Observations of the Sunyaev-Zel'dovich effect provide a nearly redshift-independent means of detecting galaxy clusters.

K

Kelvin-Helmholtz instability

The Kelvin-Helmholtz instability (after Lord Kelvin and Hermann von Helmholtz) can occur when there is velocity shear in a single continuous fluid, or where there is a velocity difference across the interface between two fluids. An example is wind blowing over water: The instability manifests in waves on the water surface. More generally, clouds, the ocean, Saturn's bands, Jupiter's Red Spot, and the sun's corona show this instability.

L

LINERS

Straight from Sturm et al. (2006):
Since their identification as a class of galactic nuclei more than 25 years ago (Heckman, 1980), the nature of low-ionization nuclear emission-line regions (LINERs) has remained controversial. *Their optical spectra are characterized by enhanced narrow emission lines of low-ionization species*, quite distinct from those of both H II regions and classical active galactic nuclei (AGNs). They are found in one-third to one-half of all types nearby galaxies (e.g., Ho et al., 1997). In many LINERs the emission is concentrated near the nucleus (a few times 100 pc; e.g, Pogge et al., 2000), but in others it extends over larger regions, up to a few kiloparsecs Veilleux et al. (1995). There is substantial evidence that many LINERs are powered by accretion onto massive black holes and that these objects, due to low accretion rates, constitute the low-luminosity end of the AGN class (Quataert, 2001; Kewley et al., 2006). If many LINERs at low and high redshifts are indeed low-luminosity AGNs, this would have a significant impact on major issues in astronomy such as the growth history of central black holes and the relation of AGNs to galaxy formation and evolution.

N

Navier-Stokes equations

In physics, the Navier-Stokes equations, named after Claude-Louis Navier and George Gabriel Stokes, describe the motion of viscous fluid substances. These balance equations arise from applying Newton's second law to fluid motion, together with the assumption that the stress in the fluid is the sum of a diffusing viscous term (proportional to the gradient of velocity) and a pressure term - hence describing viscous flow. The main difference between them and the simpler Euler equations for inviscid flow is that Navier-Stokes equations also factor in the Froude limit (no external field) and are not conservation equations, but rather a dissipative system, in the sense that they cannot be put into the quasilinear homogeneous form:

P

Planck's law

Planck's law describes the spectral density of electromagnetic radiation emitted by a black body in thermal equilibrium at a given temperature T. The spectral radiance of a body, B_ν, describes the amount of energy given off as radiation of different frequencies. It is measured in terms of the power emitted per unit area of the body, per unit solid angle that the radiation is measured over, per unit frequency. The SI units of B_ν are W sr^{-1}m^{-2}Hz^{-1}, while those of $_\lambda$ are W sr^{-1} m^{-3}.

Planck showed that the spectral radiance of a body for frequency ν at absolute temperature T is given by

$$B_\nu(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{k_\mathrm{B}T}} - 1} \tag{10}$$

where k_B is the Boltzmann constant, h is the Planck constant, and c is the speed of light in the medium.

The spectral radiance can also be expressed per unit wavelength λ instead of per unit frequency. In this case, it is given by

$$B_\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_\mathrm{B}T}} - 1} \tag{11}$$

The law may also be expressed in other terms, such as the number of photons emitted at a certain wavelength, or the energy density in a volume of radiation.

R

Radiative cooling

Radiative cooling is the process by which a body loses heat by thermal radiation.

Rayleigh-Jeans Law

In physics, the Rayleigh-Jeans Law is an approximation to the spectral radiance of electromagnetic radiation as a function of wavelength from a black body at a given temperature through classical arguments. For wavelength λ, it is:

$$B_\lambda(T) = \frac{2ck_\mathrm{B}T}{\lambda^4} \tag{12}$$

where B_λ is the spectral radiance; the power emitted per unit emitting area, per steradian, per unit wavelength, c is the speed of light, k_B is the Boltzmann constant and T is the temperature in Kelvin. For frequency ν the expression is instead

$$B_\nu(T) = \frac{2\nu^2 k_\mathrm{B}T}{c^2}. \tag{13}$$

The Rayleigh-Jeans law agrees with experimental results at large wavelengths (low frequencies) but strongly disagrees at short wavelengths (high frequencies). This inconsistency between observations and the predictions of classical physics is commonly known as the *Ultraviolet Catastrophe*. Its resolution in 1900 with the derivation by Max Planck of Planck's law, which gives the correct radiation at all frequencies, was a foundational aspect of the development of quantum mechanics in the early 20th century.

Rayleigh-Taylor instability

The Rayleigh-Taylor instability, or RT instability (after Lord Rayleigh and G. I. Taylor), is an instability of an interface between two fluids of different densities which occurs when the lighter fluid is pushing the heavier fluid.

Reddening

Reddening occurs due to the light scattering off dust and other matter in the interstellar medium. Reddening preferentially removes shorter wavelength photons from a radiated spectrum while leaving behind the longer wavelength photons (in the optical, light that is redder), leaving the spectroscopic lines unchanged.

In any photometric system interstellar reddening can be described by color excess, defined as the difference between an object's observed color index and its intrinsic color index (sometimes referred to as its normal color index). An object's intrinsic color index is the theoretical color index which it would have if unaffected by extinction. In the UBV photometric system the color excess E_{B-V} is related to the B-V colour by: $E_{B-V} = (B-V)_{\text{observed}} - (B-V)_{\text{intrinsic}}$.

Reflection-dominated

Reprocesessing

Reprocesessing, thermal

The thermal reprocessing hypothesis in AGN is where EUV/X-ray photons are reprocessed by the accretion disc into optical/UV photons.

Reynolds Number

Reynolds number (Re) is used to predict the transition from laminar to turbulent flow.
At low Reynolds numbers, flows tend to be dominated by laminar (sheet-like) flow, while at high Reynolds numbers turbulence results from differences in the fluid's speed and direction, which may sometimes intersect or even move counter to the overall direction of the flow (eddy currents).

The Reynolds number is defined as

$$\mathrm{Re} = \frac{\rho u L}{\mu} = \frac{uL}{\nu} \tag{14}$$

where:
ρ is the density of the fluid (SI units: kg/m3)
u is the flow speed (m/s)
L is a characteristic linear dimension (m)
μ is the dynamic viscosity of the fluid (Pas or Ns/m2 or kg/(ms))
ν is the kinematic viscosity of the fluid (m2/s).

Osborne Reynolds was a pioneer in the study of fluid dynamics, performing an elegant experiment to demonstrate that the critical transition point between the two types of flow could be predicted by one simple number. We now know it as the Reynolds number. twitter.com/apsphysics/status/1239144563312414721.

Rosseland opacities

(from scienceworld.wolfram.com/physics/RosselandMeanOpacity.html)
The Rosseland mean opacity $\langle\kappa\rangle$ is defined as

$$\frac{1}{\kappa}=\frac{1}{B}\int_0^\infty \frac{B_\nu}{\kappa_\nu}d\nu \tag{15}$$

where B is the total brightness (intensity), B_ν is the specific brightness, and κ_ν is the specific opacity.

(from Wikipedia)
It is customary to define the average opacity, calculated using a certain weighting scheme. Planck opacity uses the normalized Planck black body radiation energy density distribution, $B_\nu(T)$ as the weighting function, and averages κ_ν directly:

$$\begin{aligned}\kappa_{Pl} &= \frac{\int_0^\infty \kappa_\nu B_\nu(T)d\nu}{\int_0^\infty B_\nu(T)d\nu} && (16)\\ &= \left(\frac{\pi}{\sigma T^4}\right)\int_0^\infty \kappa_\nu B_\nu(T)d\nu, && (17)\end{aligned}$$

where σ is the Stefan-Boltzmann constant.

The Rosseland opacity (after Svein Rosseland), on the other hand, uses a temperature derivative of the Planck distribution,$u(\nu,T)=\partial B_\nu(T)/\partial T$ as the weighting function, and averages κ_ν^{-1},

$$\frac{1}{\kappa}=\frac{\int_0^\infty \kappa_\nu^{-1}u(\nu,T)d\nu}{\int_0^\infty u(\nu,T)d\nu}. \tag{18}$$

The photon mean free path is $\lambda_\nu=(\kappa_\nu\rho)^{-1}$. The Rosseland opacity is derived in the diffusion approximation to the radiative transport equation. It is valid whenever the radiation field is isotropic over distances comparable to or less than a radiation mean free path, such as in local thermal equilibrium. In practice, the mean opacity for Thomson electron scattering is:

$$\kappa_{\rm es}=0.20(1+X)\,{\rm cm}^2\,{\rm g}^{-1} \tag{19}$$

where X is the hydrogen mass fraction. For nonrelativistic thermal bremsstrahlung, or free-free transitions, assuming solar metallicity, it is:

$$\kappa_{\rm ff}(\rho,T)=0.64\times10^{23}(\rho[{\rm g\ \ cm^{-3}}])(T[{\rm K}])^{-7/2}\,{\rm cm}^2\,{\rm g}^{-1}.[1] \tag{20}$$

The Rosseland mean attenuation coefficient is:

$$\frac{1}{\kappa}=\frac{\int_0^\infty(\kappa_{\nu,\rm es}+\kappa_{\nu,\rm ff})^{-1}u(\nu,T)d\nu}{\int_0^\infty u(\nu,T)d\nu}] \tag{21}$$

S

Salpeter time

$$t_{\rm Sal}=M/\dot{M}=4.5\times10^7\left(\frac{\epsilon}{0.1}\right)\left(\frac{L}{L_{\rm Edd}}\right)^{-1} \tag{22}$$

where $\epsilon=L/\dot{M}c^2$ is the radiative efficiency for a QSO radiating at a fraction $L/L_{\rm Edd}$ of the Eddington luminosity. Commonly accepted values of these two key parameters for luminous QSOs are $\epsilon=0.1$ and $L/LEdd=1$. Martini, P. (QSO Lifetimes; http://adsabs.harvard.edu/abs/2004cbhg.symp..169M).

This critical accretion rate, [the Eddington mass accretion rate], is proportional to the mass of the accreting object, which implies that the mass of an object that is growing at the maximal (Eddington) accretion grows exponentially on a timescale known as the Salpeter time,

$$t_{\rm Sal} = \frac{\epsilon \sigma_T c}{4\pi G m_p} \quad (23)$$

$$= \frac{\epsilon 6.65 \times 10^{-29} \cdot 3 \times 10^8}{4\pi \cdot 1.6726 \times 10^{-27} \cdot 6.674 \times 10^{-11}} \text{ seconds} \quad (24)$$

$$\approx 45\epsilon_{0.1} 10^6 \text{ years} \quad (25)$$

from “Massive Black Hole Growth and Formation” from Paolo Coppi.

Specific entropy

Soft Xrays

See:: X-rays, Soft.

Soltan Argument

$$\frac{\epsilon}{1-\epsilon} \rho_{\rm BH} c^2 = \int e(z)(1+z)dz \quad (26)$$

$e(z)dz$: present energy density from AGN in redshift range z to $z + dz$.
$\rho_{\rm BH}$: mean cosmic density of nuclear black holes.
η: radiative efficiency
The Soltan argument works approximately for η ≈0.1, so observed AGN must account for most of nuclear black hole growth.

Refs:
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www.bo.astro.it/ vignali/PhD.../Merloni_PhD_Bologna_Tuesday.pptx www.astro.yale.edu/coppi/pubs/bhgrowth4.pd
http://ned.ipac.caltech.edu/level5/March02/Ferrarese/Fer2.html

StefanBoltzmann law

The StefanBoltzmann law describes the power radiated from a black body in terms of its temperature. Specifically, the StefanBoltzmann law states that the total energy radiated per unit surface area of a black body across all wavelengths per unit time

$j^\star$ (also known as the black-body radiant emittance) is directly proportional to the fourth power of the black body's thermodynamic temperature T:

$$j^\star = \sigma T^4, \quad (27)$$

The constant of proportionality σ, called the StefanBoltzmann constant, is derived from other known physical constants. The value of the constant is

$$\sigma = \frac{2\pi^5 k^4}{15 c^2 h^3} = 5.670373 \times 10^{-8}\,\mathrm{W\,m^{-2}K^{-4}} \quad (28)$$

where k is the Boltzmann constant, h is Planck's constant, and c is the speed of light in a vacuum.

The radiance (watts per square metre per steradian) is given by

$$L = \frac{j^\star}{\pi} = \frac{\sigma}{\pi} T^4. \quad (29)$$

Synchrotron Radiation

Synchrotron Self-Absorption

Aaron Parsons video

Synchrotron Self-Compton

Electrons undergoing synchrotron radiation create a photon bath which other electrons will then interact with via inverse Compton scattering. Recall that for original (unprocessed) synchrotron radiation, that F_ν, between some minimum and maximum frequency cut-off, goes as $K\nu^\alpha$, and that the number of photons per γ is $\frac{dN}{d\gamma} = N_0\gamma^s$, where $\alpha = \frac{1+s}{2}$. These frequency cut-offs were set by $\gamma_{\rm min}^2\nu_{\rm cyc}$ and $\gamma_{\rm max}^2\nu_{\rm cyc}$. After this radiation is processed by SSC, approximately every photon is upscattered to a new energy $\frac{4}{3}\gamma^2\nu$.

T

Thomson cross-section

$N_{\rm H} \geq \sigma_{\rm T}^{-1} \simeq 1.5\times10^{24}$ cm^{-2}.

For an electron:

$$\sigma_{\rm T} = \frac{8\pi}{3}\left(\frac{\alpha\hbar c}{mc^2}\right)^2 = 0.6652\times10^{-24}\ \mathrm{cm}^{-2} \tag{30}$$

Thomson scattering

Thomson scattering is the elastic scattering of electromagnetic radiation by a free charged particle. It is just the low-energy limit of Compton scattering: the particle kinetic energy and photon frequency are the same before and after the scattering. This limit is valid as long as the photon energy is much less than the mass energy of the particle: $\nu \ll mc^2/h$.

V

Virial Temperature

The mean temperature at which a gravitationally bound system would satisfy the *virial theorem*. For a system of mass M and radius R with constant density, the gravitational energy per unit mass is $W = GM/R$. The kinetic energy per unit mass is $E = (3/2)k_BT_{\rm vir}/\mu$, where k is Boltzmann's constant and μ the mean molecular weight. According to the virial theorem, $E = W/2$, which leads to the virial temperature

$$T_{\rm vir} = (1/3)(GM/kR). \tag{31}$$

Virial Theorem

The virial theorem states that, for a stable, self-gravitating, spherical distribution of equal mass objects (stars, galaxies, etc), the total kinetic energy of the objects is equal to minus 1/2 times the total gravitational potential energy. In other words, the potential energy must equal the kinetic energy, within a factor of two.

W

Wien's Approximation Law

Wien's Approximation, also sometimes called Wien's law or the Wien Distribution law, is a law of physics used to describe the spectrum of thermal radiation (frequently called the blackbody function). The equation does accurately describe the short wavelength (high frequency) spectrum of thermal emission from objects, but it fails to accurately fit the experimental data for long wavelengths (low frequency) emission. The law may be written as

$$I(\nu,T) = \frac{2h\nu^3}{c^2}e^{-\frac{h\nu}{kT}} \tag{32}$$

The Wien approximation may be derived from Planck's law by assuming $h\nu \gg kT$. When this is true, then

$$\frac{1}{e^{\frac{h\nu}{kT}} - 1} \approx e^{-\frac{h\nu}{kT}} \tag{33}$$

and so Planck's law approximately equals the Wien approximation at high frequencies.

Wien's Displacement Law

Wien's Displacement law states that the black body radiation curve for different temperature peaks at a wavelength that is inversely proportional to the temperature. The shift of that peak is a direct consequence of the Planck radiation law, which describes the spectral brightness of black body radiation as a function of wavelength at any given temperature.

Formally, Wien's displacement law states that the spectral radiance of black body radiation per unit wavelength, peaks at the wavelength max given by:

$$\lambda_{\max} = \frac{b}{T} \tag{34}$$

where T is the absolute temperature in Kelvins. b is a constant of proportionality called Wien's displacement constant, equal to $2.8977729(17) \times 10^{-3}$ m K.

X

X-rays, Hard

X-rays, Soft

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