

- **compPS: Comptonization, Poutanen & Svensson**

Comptonization spectra computed for different geometries using exact numerical solution of the radiative transfer equation. The computational "iterative scattering method" is similar to the standard Lambda-iteration and is described in Poutanen J., Svensson R., 1996, ApJ, 470, 249 (PS96). The Compton scattering kernel is the exact one as derived by Jones F. C., 1968, Phys. Rev., 167, 1159 (see PS96 for references).

Comptonization spectra depend on the geometry (slab, sphere, hemisphere, cylinder), Thomson optical depth τ , parameters of the electron distribution, spectral distribution of soft seed photons, the way seed soft photons are injected to the electron cloud, and the inclination angle of the observer.

The resulting spectrum is reflected from the cool medium according to the computational method of Magdziarz & Zdziarski (1995) (see reflect, pexrav, pexriv models). rel_refl is the solid angle of the cold material visible from the Comptonizing source (in units 2π), other parameters determine the abundances and ionization state of reflecting material (Fe_ab_re , Me_ab , xi , Tdisk). The reflected spectrum is smeared out by rotation of the disk due to special and general relativistic effects using "diskline"-type kernel (with parameters Betor10 , Rin , Rout).

Electron distribution function can be Maxwellian, power-law, cutoff Maxwellian, or hybrid (with low temperature Maxwellian plus a power-law tail).

Possible geometries include plane-parallel slab, cylinder (described by the height-to-radius ratio H/R), sphere, or hemisphere. By default the lower boundary of the "cloud" (not for spherical geometry) is fully absorptive (e.g. cold disk). However, by varying covering factor parameter cov_fac , it may be made transparent for radiation. In that case, photons from the "upper" cloud can also be upscattered in the "lower" cloud below the disk. This geometry is that for an accretion disk with cold cloudlets in the central plane (Zdziarski, Poutanen, et al. 1998, MNRAS, 301, 435). For cylinder and hemisphere geometries, an approximate solution is obtained by averaging specific intensities over horizontal layers (see PS96). For slab and sphere geometries, no approximation is made.

The seed photons can be injected to the electron cloud either isotropically and homogeneously through out the cloud, or at the bottom of the slab, cylinder, hemisphere or center of the sphere (or from the central plane of the slab if $\text{cov_frac} \neq 1$). For the sphere, there exist a possibility ($\text{IGEOM}=-5$) for photon injection according to the eigenfunction of the diffusion equation $\sin(\pi \tau' / \tau) / (\pi \tau' / \tau)$, where τ' is the optical depth measured from the center (see Sunyaev & Titarchuk 1980).

Seed photons can be black body (bbbodyrad) for $\text{Tbb} > 0$ or multicolor disk (diskbb) for $\text{Tbb} < 0$. The normalization of the model also follows those models: (1) $\text{Tbb} > 0$, $K = (\text{RKM})^2 / (\text{D10})^2$, where D10 is the distance in units of 10 kpc and RKM is the source radius in km; (2) $\text{Tbb} < 0$ $K = (\text{RKM})^2 / (\text{D10})^2 \cos(\theta)$, where θ is the inclination angle.

Thomson optical depth of the cloud is not always good parameter to fit. Instead the Compton parameter $y=4 * \tau * \Theta$ (where $\Theta = T_e \text{ (keV)} / 511$) can be used. Parameter y is directly related to the spectral index and therefore is much more stable in fitting procedure. The fitting can be done taking 6th parameter negative, and optical depth then can be obtained via $\tau = y / (4 * T_e / 511)$.

The region of parameter space where the numerical method produces reasonable results is constrained as follows : 1) Electron temperature $T_e > 10 \text{ keV}$; 2) Thomson optical depth $\tau < 1.5$ for slab geometry and $\tau < 3$, for other geometries.

par1 = T_e , electron temperature in keV
 par2 = p , electron power-law index [$N(\gamma) = \gamma^{-p}$]
 par3 = g_{\min} , minimum Lorentz factor γ
 par4 = g_{\max} , maximum Lorentz factor γ
 (a) if any of g_{\min} or $g_{\max} < 1$ then Maxwellian electron distribution with parameter T_e
 (b) if $T_e = 0$. then power-law electrons with parameters p , g_{\min} , g_{\max}
 (c) if both $g_{\min}, g_{\max} \geq 1$ but $g_{\max} < g_{\min}$ then cutoff Maxwellian with T_e , p , g_{\min} (cutoff Lorentz factor) as parameters
 (d) if $T_e \neq 0$, g_{\min} , $g_{\max} \geq 1$ then hybrid electron distribution with parameters T_e , p , g_{\min} , g_{\max}
 par5 = T_{bb} , temperature of soft photons
 $T_{bb} > 0$ blackbody
 $T_{bb} < 0$ multicolor disk with inner disk temperature T_{bb}
 par6 = if > 0 : τ , vertical optical depth of the corona
 if < 0 : $y = 4 * \Theta * \tau$
 limits: for the slab geometry - $\tau < 1$
 if say $\tau \sim 2$ increase MAXTAU to 50
 for sphere - $\tau < 3$
 par7 = geom, 0 - approximate treatment of radiative transfer using escape probability for a sphere (very fast method); 1 - slab; 2 - cylinder; 3 - hemisphere; 4,5 - sphere
 input photons at the bottom of the slab, cylinder, hemisphere or center of the sphere (or from the central plane of the slab if cov_fac not 1). if < 0 then geometry defined by |geom| and sources of incident photons are isotropic and homogeneous.
 -5 - sphere with the source of photons distributed according to the eigenfunction of the diffusion equation
 $f(\tau') = \sin(\pi * \tau' / \tau) / (\pi * \tau' / \tau)$ where τ' varies between 0 and τ .
 par8 = H/R for cylinder geometry only
 par9 = cosIncl, cosine of inclination angle
 (if < 0 then only black body)
 par10 = cov_fac, covering factor of cold clouds
 if geom = +/- 4,5 then cov_fac is dummy

par11 = R , amount of reflection $\Omega/(2\pi)$
(if $R < 0$ then only reflection component)
par12 = FeAb, iron abundance in units of solar
par13 = MeAb, abundance of heavy elements in units of solar
par14 = ξ , disk ionization parameter $L/(nR^2)$
par15 = temp, disk temperature for reflection in K
par16 = β , reflection emissivity law (r^β)
if $\beta = -10$ then non-rotating disk
if $\beta = 10$ then $1 - \sqrt{6/r_g})/r_g^{**3}$
par17 = R_{in}/R_g , inner radius of the disk (Schwarzschild units)
par18 = R_{out}/R_g , outer radius of the disk
par19 = redshift