AGN obscuration by clouds orbiting close to SMBH

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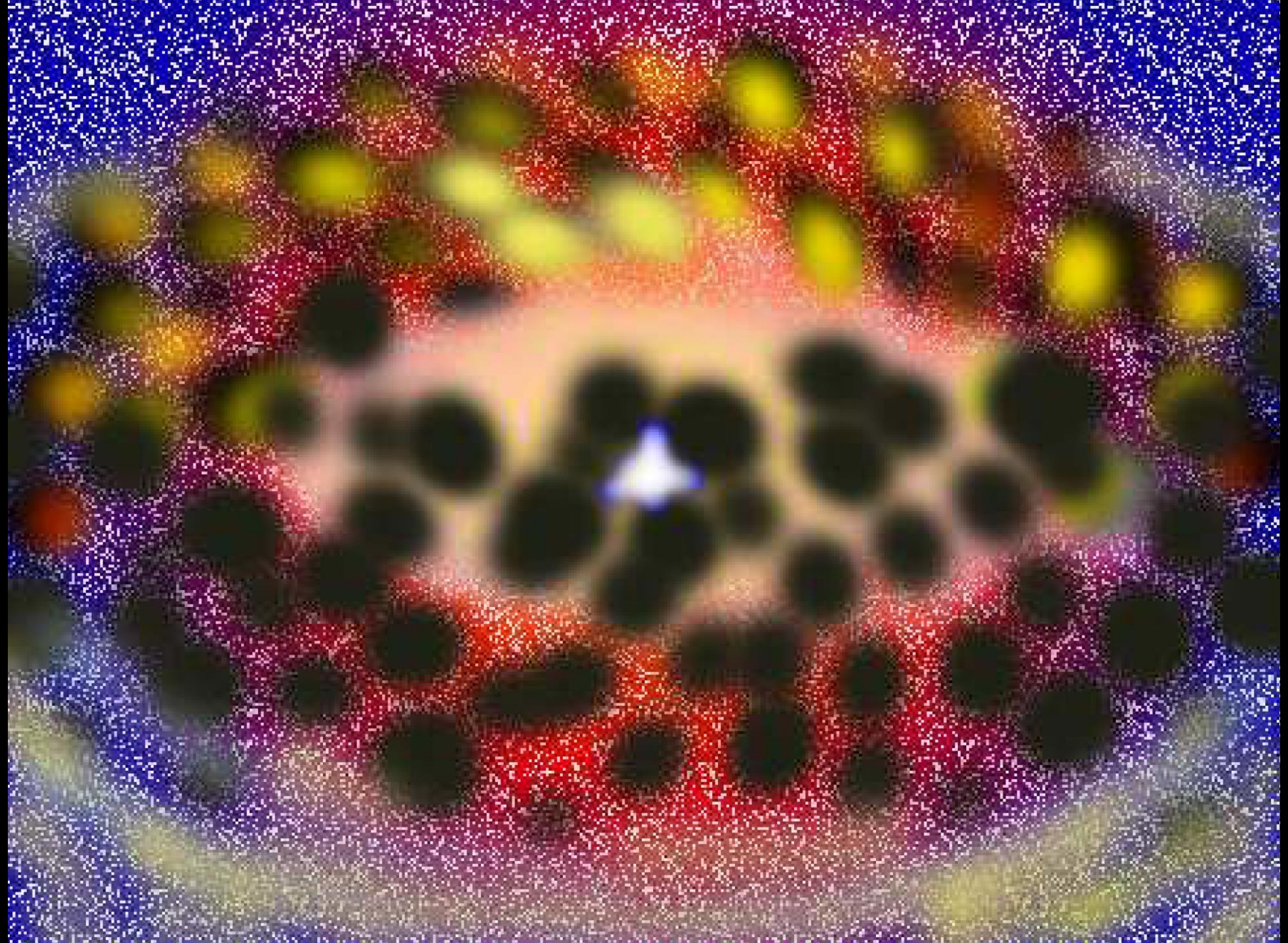


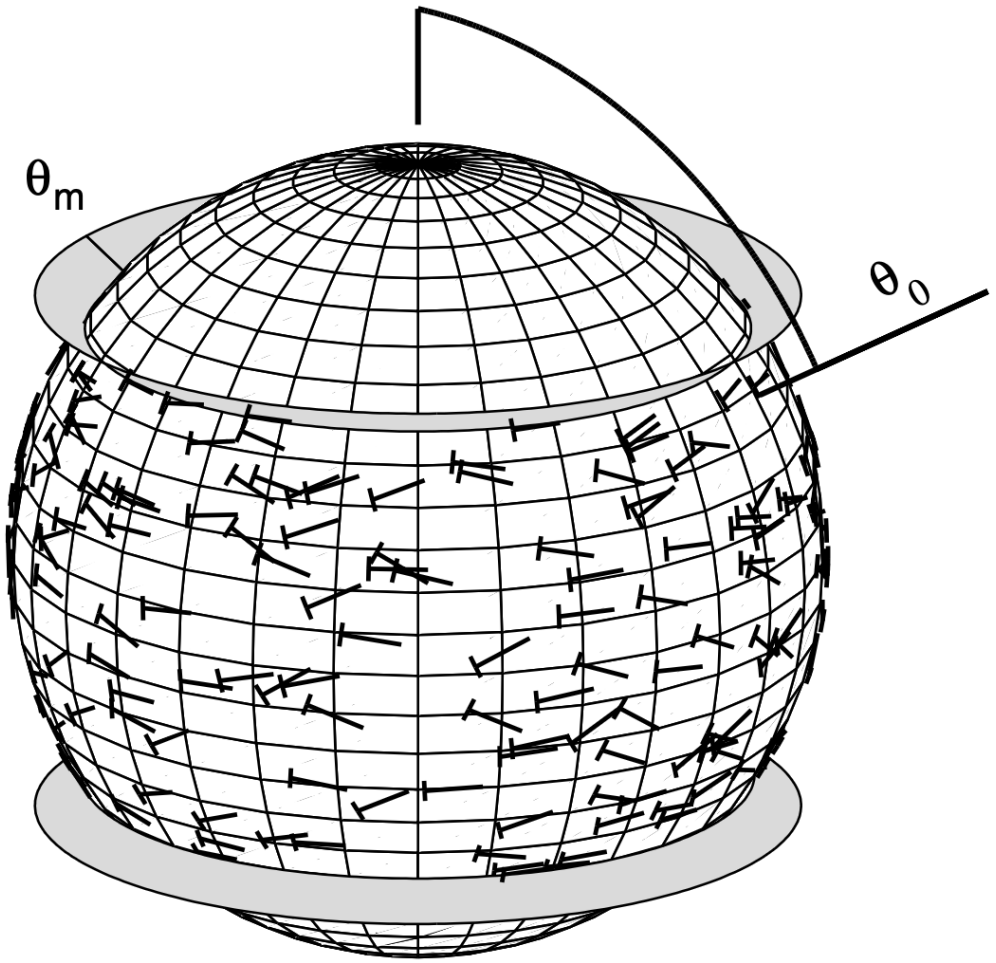


Figure 2. A representation of the cloud distribution (positions and velocities of the clouds). In this sketch we consider all the clouds as being located on the surface of a sphere. Their trajectories are characterized by a constant value of the radius r, and by maximum excursion $\theta_{\rm m}$ from the equatorial plane. The clouds are distributed randomly within the allowed range of latitude, which also restricts directions of the cloud velocities (indicated by short dashes). The observer's inclination angle θ_0 is also shown.

Karas et al. (2001), MNRAS

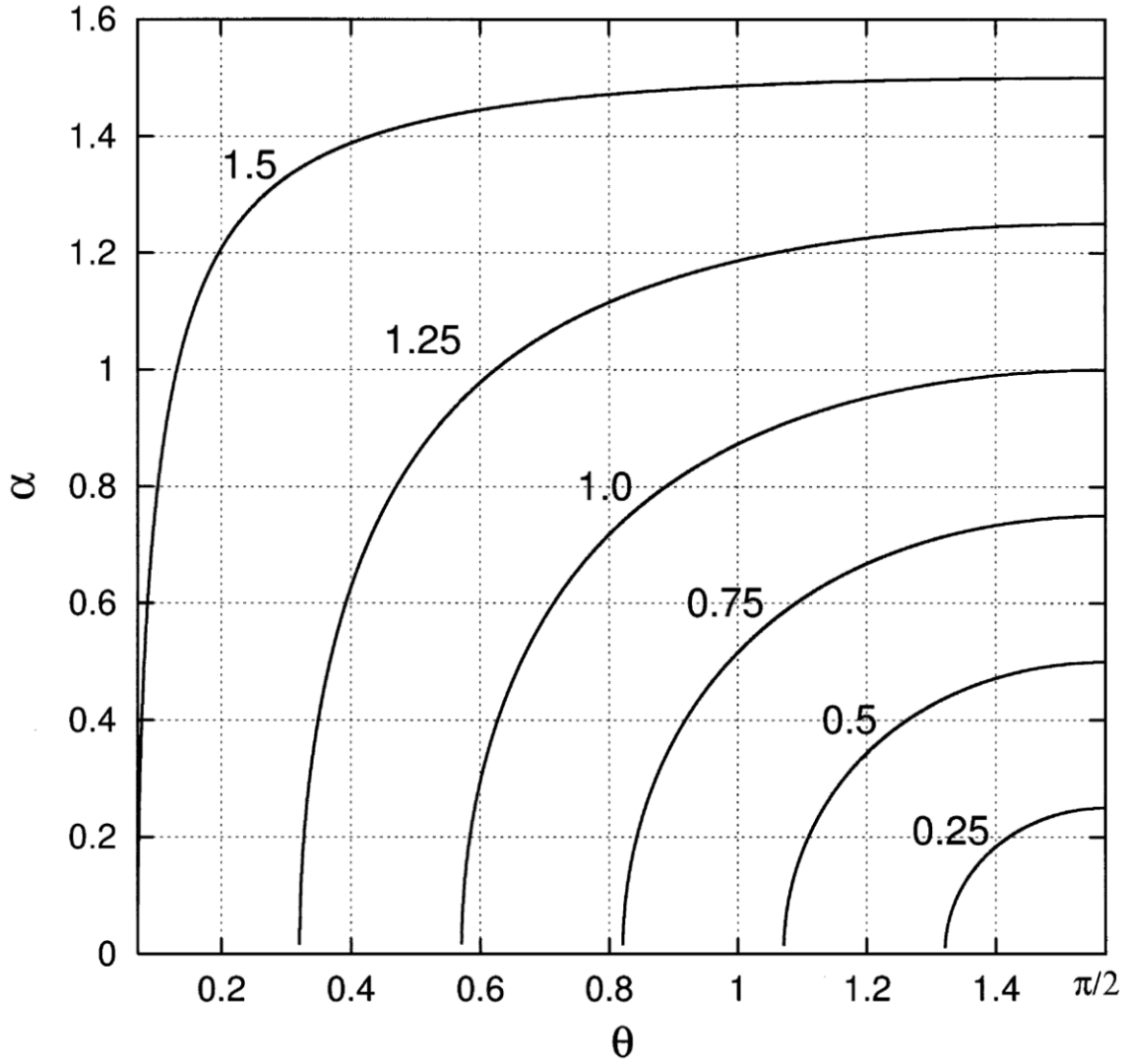


Figure 3. The range of allowed values of angle α constraining the velocity direction of the clouds as a function of θ (cf. equation 1). The curves are labelled with the corresponding latitudinal boundary θ_m of the cloud belt, which adopts values from $\theta_m = \pi/2$ (strictly spherical distribution) down to $\theta_m = 0$ (the equatorial ring).

The velocity of the clouds at points along the $r = \text{const}$ surface and its direction define the angle α:

$$\boldsymbol{v} = v_k(\cos\alpha \boldsymbol{e}_\phi - \sin\alpha \boldsymbol{e}_\theta). \quad (1)$$

The range of possible values of α is determined by the angular width θ_m of the cloud distribution. Straightforward trigonometry gives the relation for the maximum α of the cloud velocities,

$$\sin\alpha = \pm(\cos\theta\cot\theta\cot\theta_m\cos\theta_m - \sin\theta\sin\theta_m) \times(1 - \cos^2\theta\sin^{-2}\theta_m)^{1/2} \mp \cos^2\theta\sin^{-1}\theta_m(1 - \cot^2\theta\cot^2\theta_m)^{1/2}. \quad (2)$$

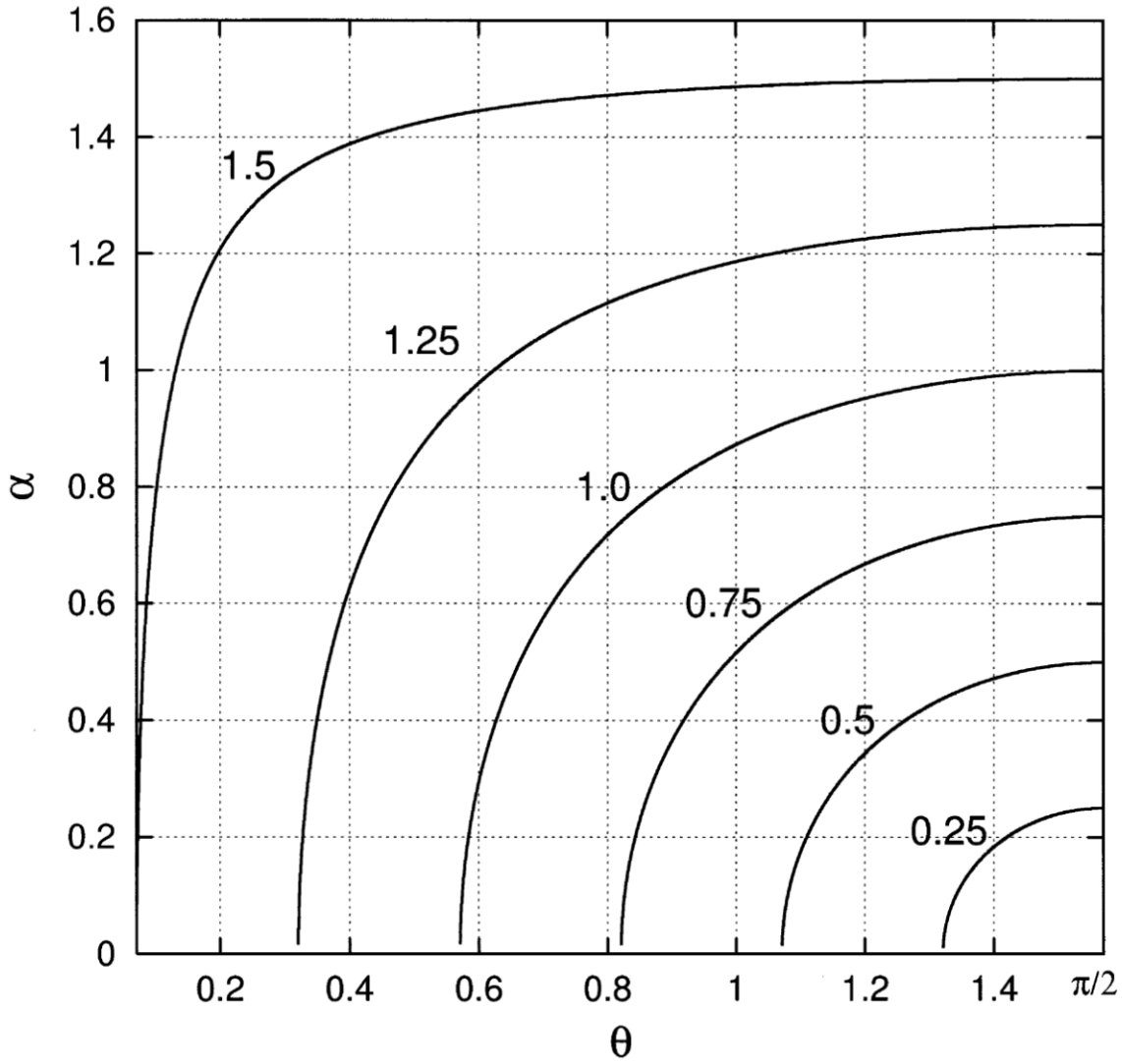


Figure 3. The range of allowed values of angle α constraining the velocity direction of the clouds as a function of θ (cf. equation 1). The curves are labelled with the corresponding latitudinal boundary $\theta_{\rm m}$ of the cloud belt, which adopts values from $\theta_{\rm m} = \pi/2$ (strictly spherical distribution) down to $\theta_{\rm m} = 0$ (the equatorial ring).

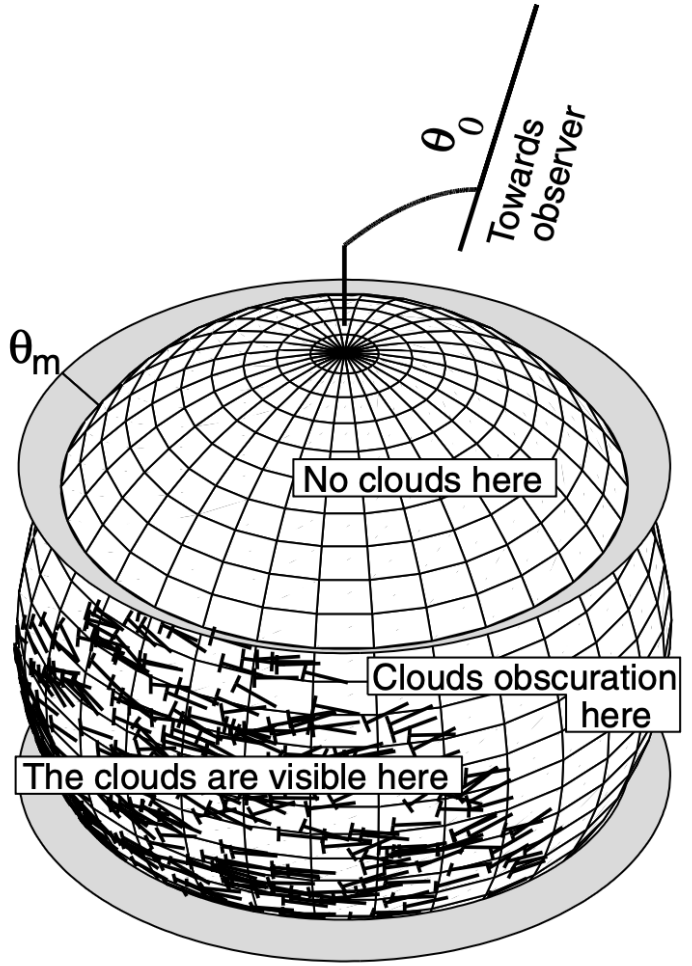


Figure 4. A view of the cloud distribution in the case of non-negligible obscuration. Positions and velocities of those clouds that fulfil conditions of visibility (equation 4) are shown. In comparison with Fig. 2, only a fraction of the clouds contribute to the observed spectrum: those moving more or less perpendicularly to the observer's line of sight. The direction towards the observer is shown with inclination angle θ_0. Different regions are indicated on the sphere according to visibility of the clouds. The clouds do not reach high latitudes, and they cannot be seen by the observer once they approach the rim of the projected image. This figure corresponds to parameters $\theta_{\rm m} = 30°$, $\theta_0 = 60°$, $\omega = 60°$ in our notation.

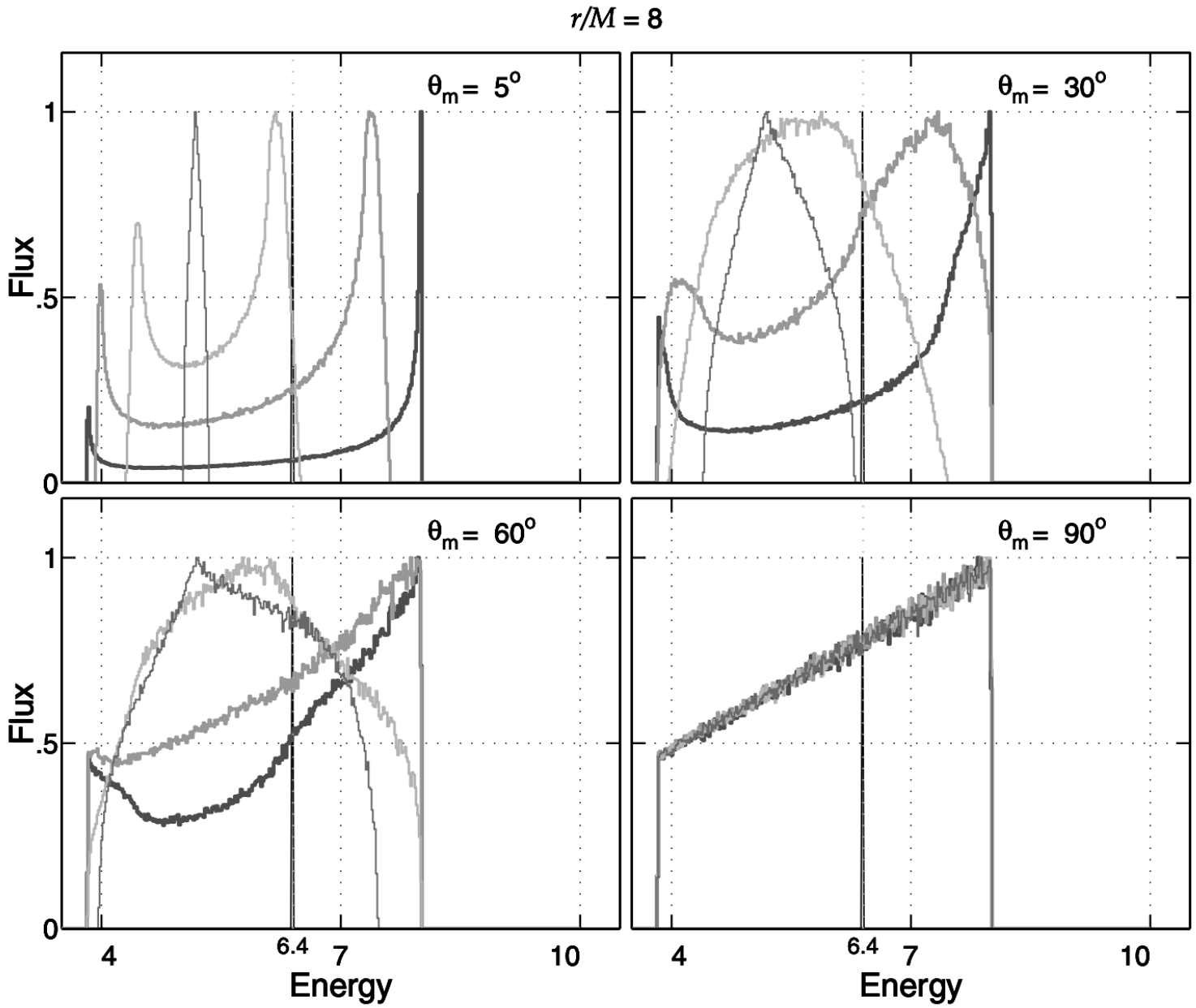
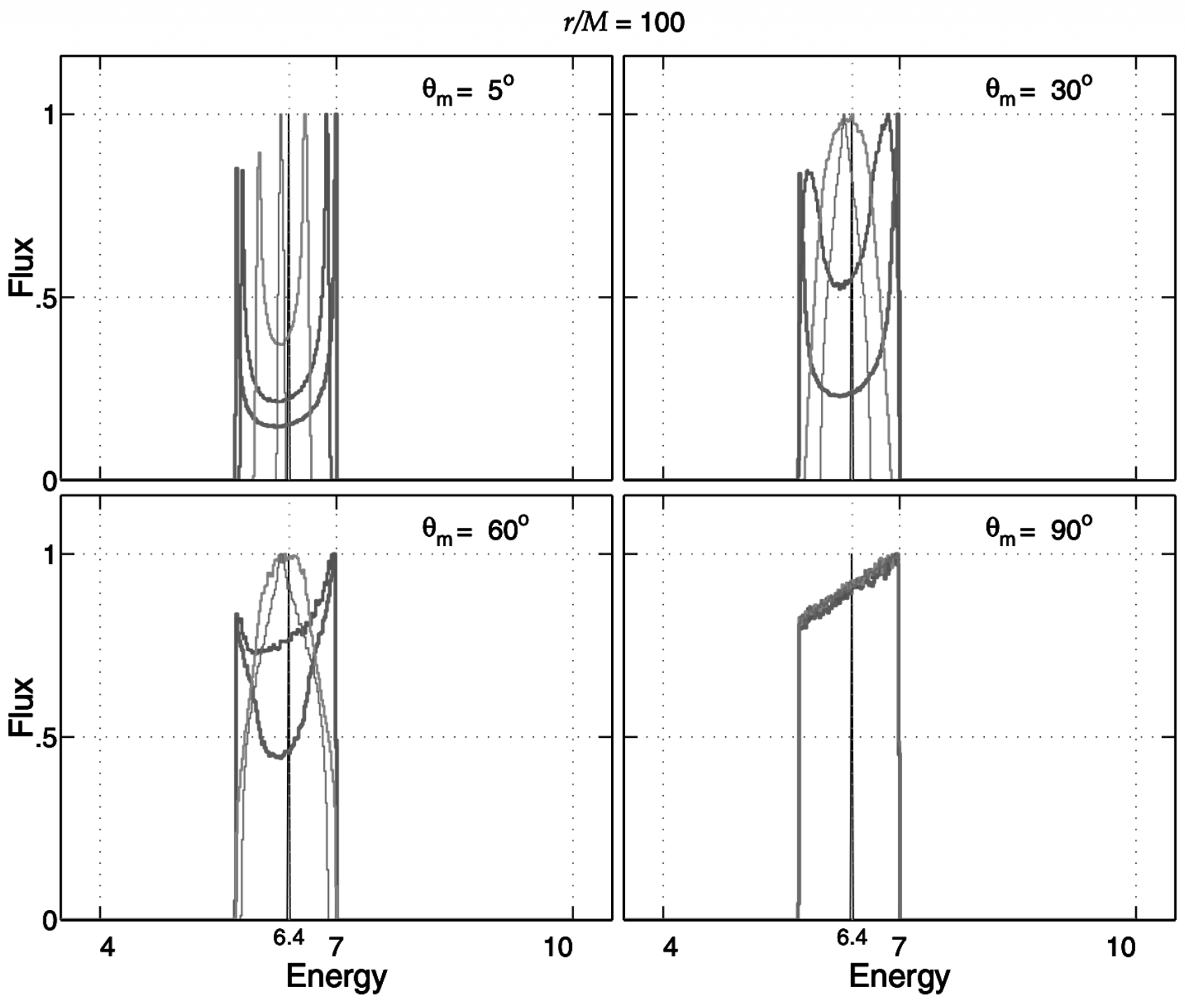


Figure 7. The expected line profile produced by the cloud sphere with $r = 8M$. The intrinsic emissivity has been assumed as a delta line at 6.4 keV. The four panels correspond to different angular widths of the cloud belt: $\theta_m = 5°$ (almost equatorial ring), 30°, 60° and 90° (strictly spherical distribution). In each panel, four curves correspond to different values of the observer inclination: $\theta_0 = 0$ (pole-on view, therefore the narrowest profile), 30°, 60°, 90° (equator-on view, the broadest profile). No obscuration is involved here. See the text for details.


r/M = 100
θm = 5°
θm = 30°
θm = 60°
θm = 90°
Flux
1
.5
0
4
6.4
7
10
Energy

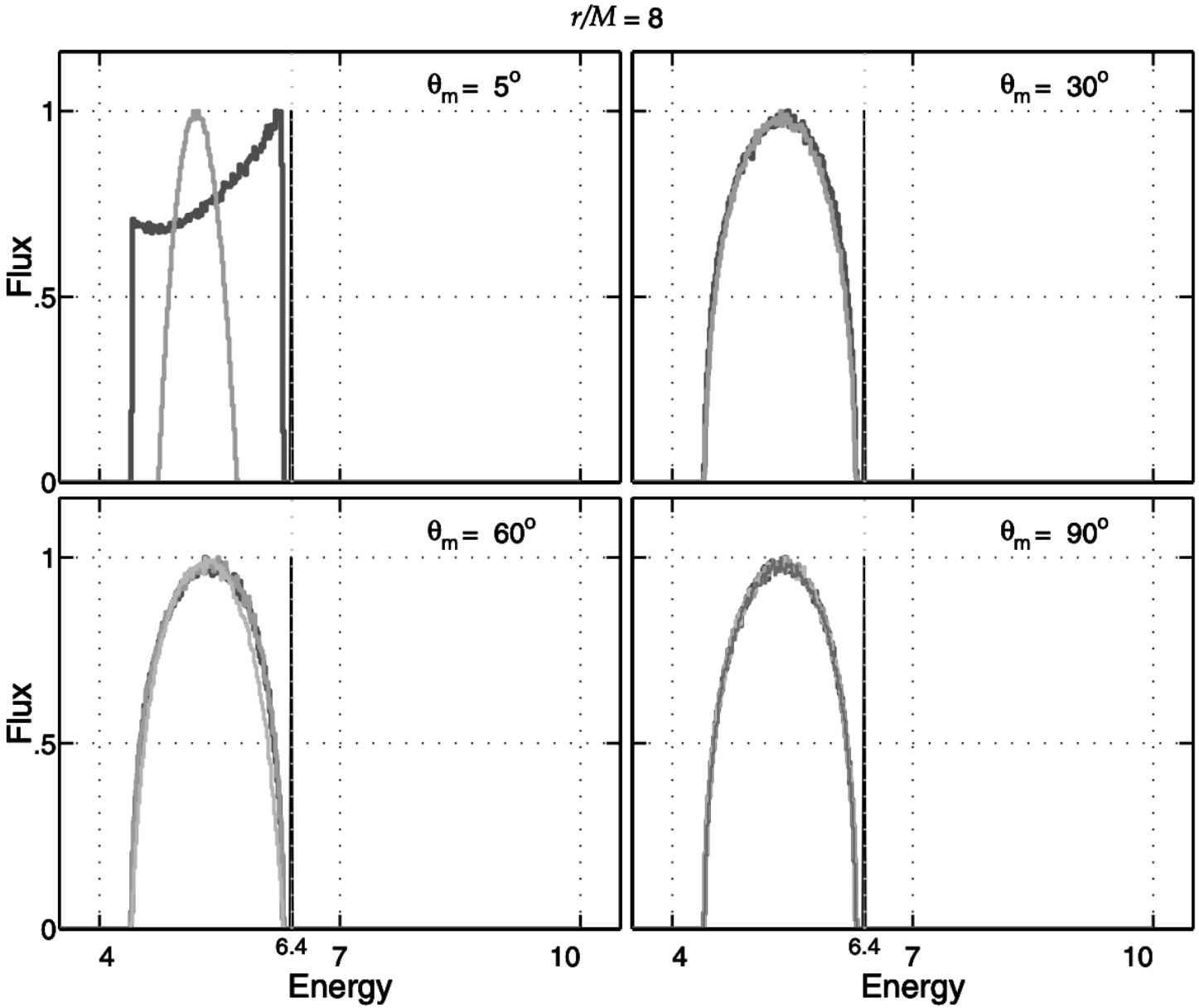


Figure 10. The predicted spectral profiles corresponding to delta-type lines as in Fig. 7, but now the obscuration parameter has been introduced with $\omega = 30°$. The dependence of the profiles on the observer's inclination is substantially reduced in comparison with the previous case of negligible obscuration. Here, $r = 8M$.

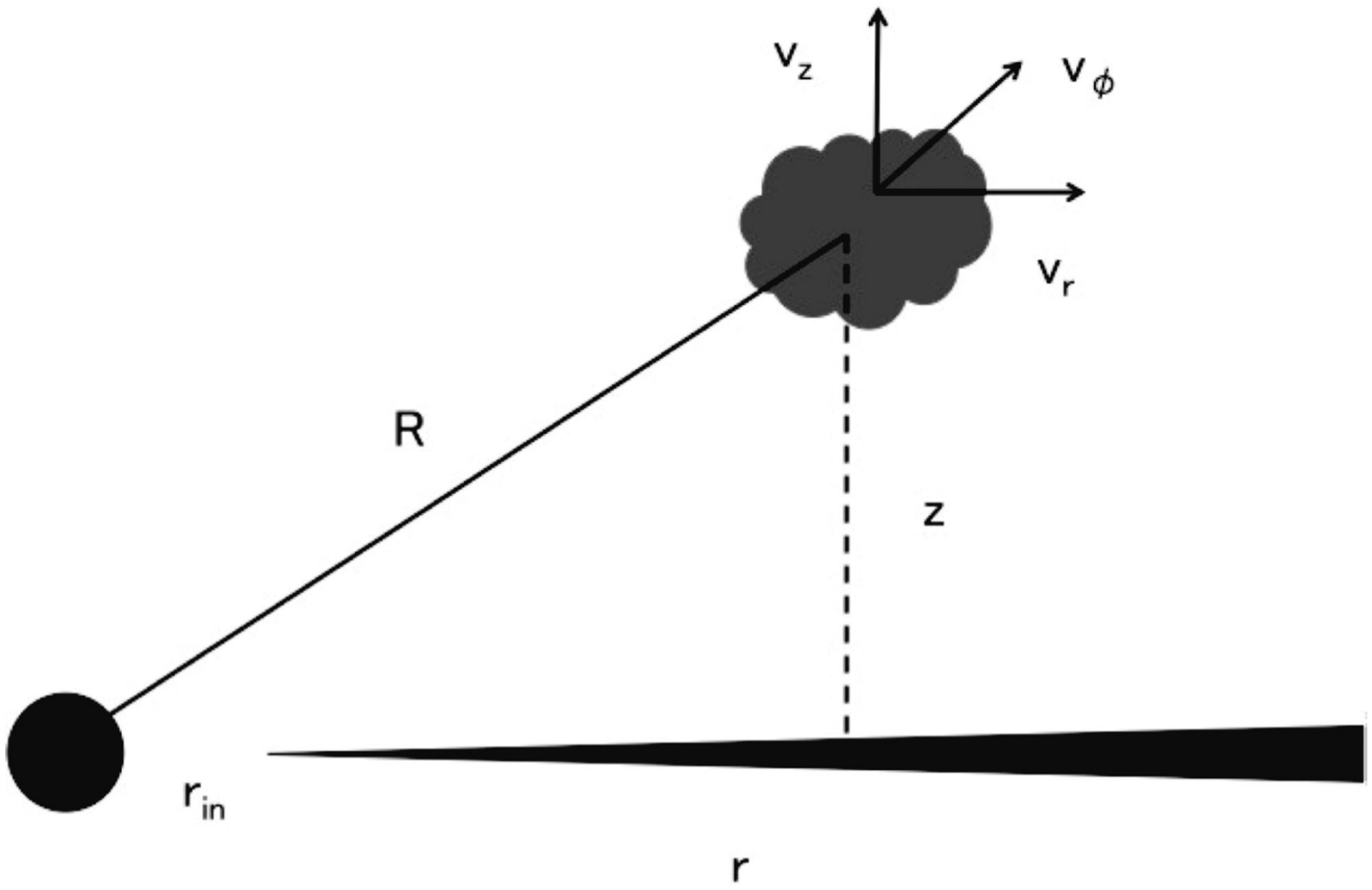


Fig. 1. Schematic picture for the present model. The stratus with finite optical depth above a luminous accretion disk experiences the gravitational force of the central black hole, the centrifugal force from the rotational motion, and the radiative force from the disk radiation field.

Nakai & Fukue (2015), PASJ

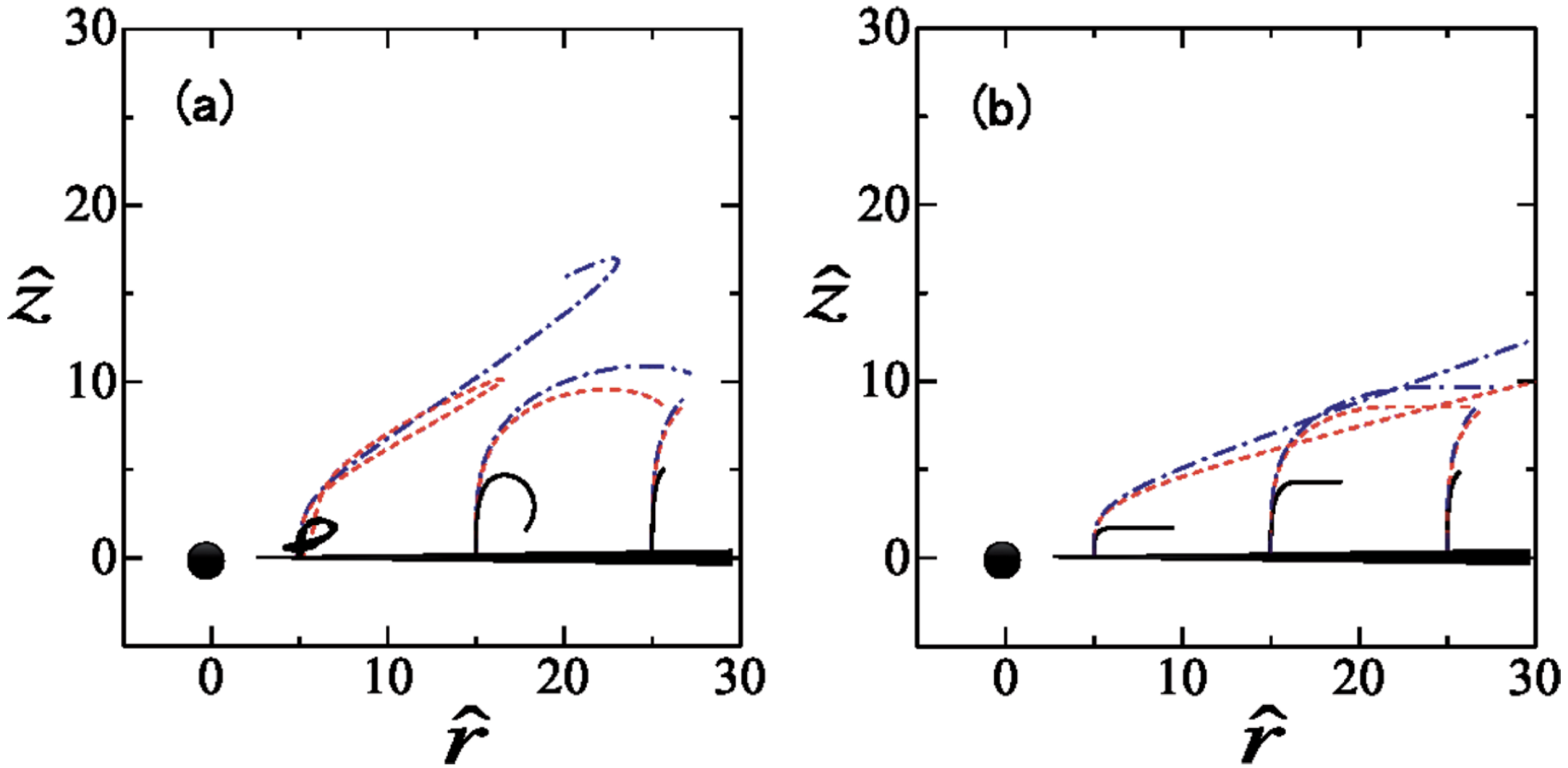


Fig. 2. Trajectories of stratus disk winds in the case of $\Gamma_d = 0.5$; (a) the Newtonian case and (b) the pseudo-Newtonian one. The solid, dashed, and chain-dotted curves denote the cases of $\tau_c = 1$, $\tau_c = 0.1$, and $\tau_c = 0.01$, respectively. (Color online)

Thank you!