The Astrophysical Journal, 973:66 (2pp), 2024 September 20 https://doi.org/10.3847/1538-4357/ad77ac


# Erratum: "Two-dimensional Study of the Propagation of Planetary Wake and the Indication of Gap Opening in an Inviscid Protoplanetary Disk" (2010, ApJ, 724, 448)

Takayuki Muto[1], Takeru K. Suzuki[2], and Shu-Ichiro Inutsuka[2]
[1] Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2-12-1 Oh-okayama, Meguro-ku, Tokyo 152-8551, Japan; muto@cc.kogakuin.ac.jp
[2] Department of Physics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan
*Received 2024 September 1; published 2024 September 19*

Section 3.3 of the published article presents the second-order perturbation theory to investigate the gap opening processes by a low-mass planet in an inviscid disk. We find some errors in the end of this subsection, where we calculate a specific model in which the source of mass flux is given by Dirac's $\delta$-functions.

The calculations are correct up to Equation (50). However, we find that the Equation (51) contains an error in the Jacobian factor and should read

$$\mathcal{F}_M(t,x) = -\frac{S_0}{2c^2}\left\{\int_{\cos^{-1}[(x-x_s)/ct]}^{\pi} d\theta\left[(x-x_s)\frac{\tan\theta}{\cos\theta}J_0\left(\frac{x-x_s}{H}\tan\theta\right)\right]\right.$$
$$\left. - \int_0^{\cos^{-1}[(x+x_s)/ct]} d\theta\left[(x+x_s)\frac{\tan\theta}{\cos\theta}J_0\left(\frac{x+x_s}{H}\tan\theta\right)\right]\right\}. \quad (1)$$

Then, we assume $0 < x < x_s$ to derive Equation (52). This equation contains another error arising from the incorrect treatment of the integral involving Dirac's $\delta$-function and should read as

$$\mathcal{F}_M(t,x) = -\frac{S_0}{2c^2}\left\{\int_{\cos^{-1}[(x-x_s)/ct]}^{\pi} d\theta\left[(x-x_s)\frac{\tan\theta}{\cos\theta}J_0\left(\frac{x-x_s}{H}\tan\theta\right)\right]\right.$$
$$\left. - \int_0^{\cos^{-1}[(x+x_s)/ct]} d\theta\left[(x+x_s)\frac{\tan\theta}{\cos\theta}J_0\left(\frac{x+x_s}{H}\tan\theta\right)\right]\right\}. \quad (2)$$

Then, we take the limit of $t \to \infty$. Instead of Equation (53), the following formula should be used:

$$\mathcal{F}_M(t,x) \sim \frac{HS_0}{2c^2}[e^{-(x_s-x)/H} - e^{-(x+x_s)/H}] = \frac{HS_0}{c^2}e^{-x_s/H}\sinh\left(\frac{x}{H}\right), \quad (3)$$

to obtain

$$\mathcal{F}_M(t,x) \sim \frac{HS_0}{2c^2}[e^{-(x_s-x)/H} - e^{-(x+x_s)/H}] = \frac{HS_0}{c^2}e^{-x_s/H}\sinh\left(\frac{x}{H}\right), \quad (4)$$

which replaces Equation (54). The discussion following Equation (54) is unchanged except on the point that the correct formula now does not diverge at $x = \pm x_s$. All the discussions and conclusions of the published article remain valid since we do not use the specific form of Equation (54) in other sections. Only the qualitative behavior of Equation (54) is used, that is, the mass flux linearly scales with $x$ in the vicinity of the planet ($x \sim 0$). This is true in Equation (3) of this erratum.

Equations (1) and (3) assume $0 < x < x_x$, as in the published article. The general solution of Equation (39) under the ansatz of Equation (48) is given by

$$\mathcal{F}_M = \frac{HS_0}{2c^2}(I(t, y = |x - x_s|) - I(t, y = |x + x_s|)), \quad (5)$$

where

$$I(t,y) = \begin{cases} \dfrac{y}{H}\displaystyle\int_0^{\sqrt{(ct/y)^2-1}} J_0\left(\frac{y}{H}\beta\right)\frac{\beta}{\sqrt{\beta^2+1}}d\beta & \text{for } ct > y \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

and for $t \to \infty$, the mass flux reaches a steady state with

$$\mathcal{F}_M(t = \infty, x) = \frac{HS_0}{2c^2}(e^{-|x-x_s|/H} - e^{-|x+x_s|/H}). \tag{7}$$

Recently, A. J. Cordwell & R. R. Rafikov (2024) have investigated the importance of the time variability of specific angular momentum in the early stages of gap opening. Their results are consistent with the those in this erratum.

## ORCID iDs

Takeru K. Suzuki https://orcid.org/0000-0001-9734-9601
Shu-Ichiro Inutsuka https://orcid.org/0000-0003-4366-6518

## References

Cordwell, A. J., & Rafikov, R. R. 2024, MNRAS, in press