

8 - 10 March 2023

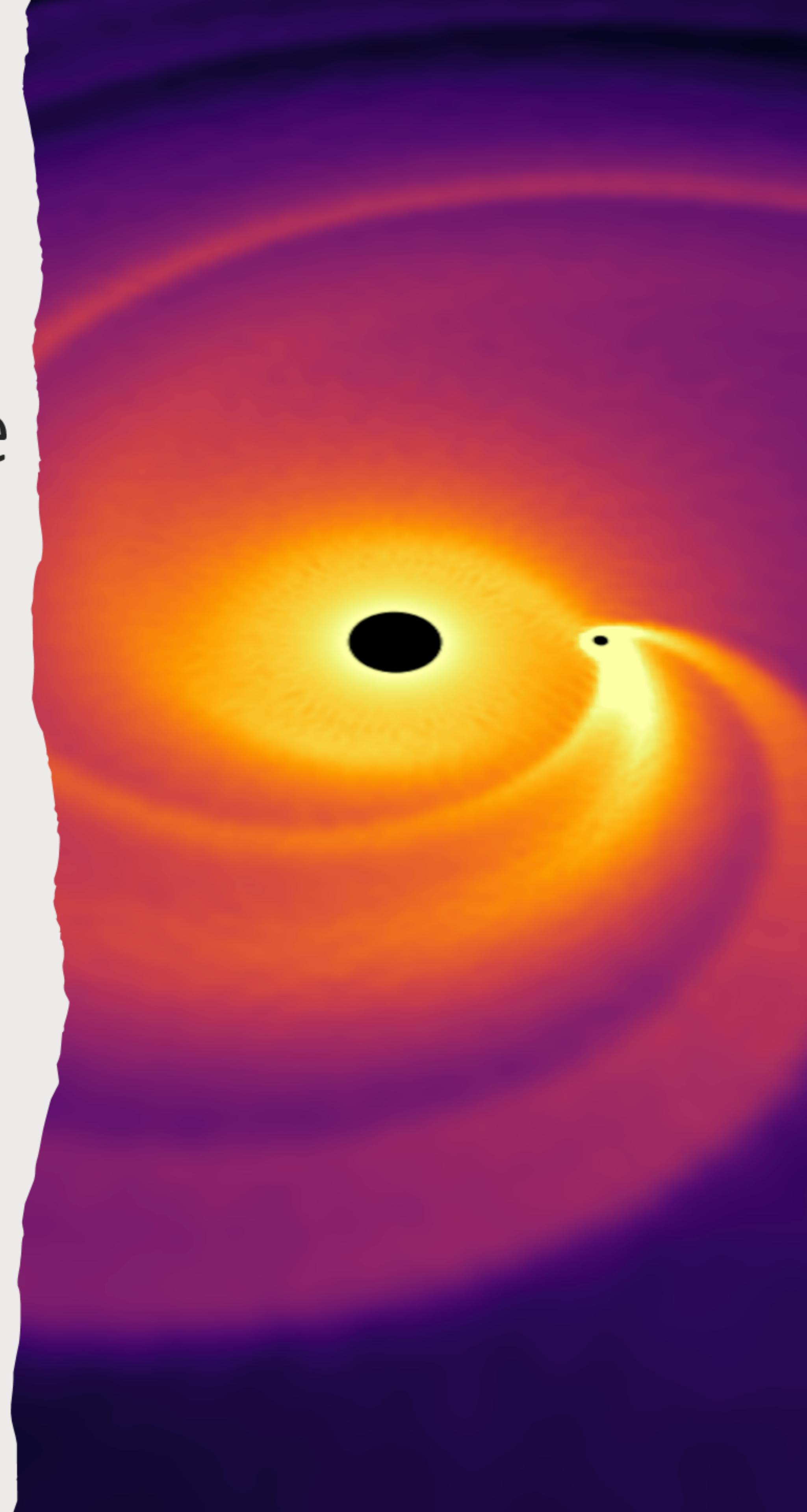
ATOMIUM Meeting winter 2023

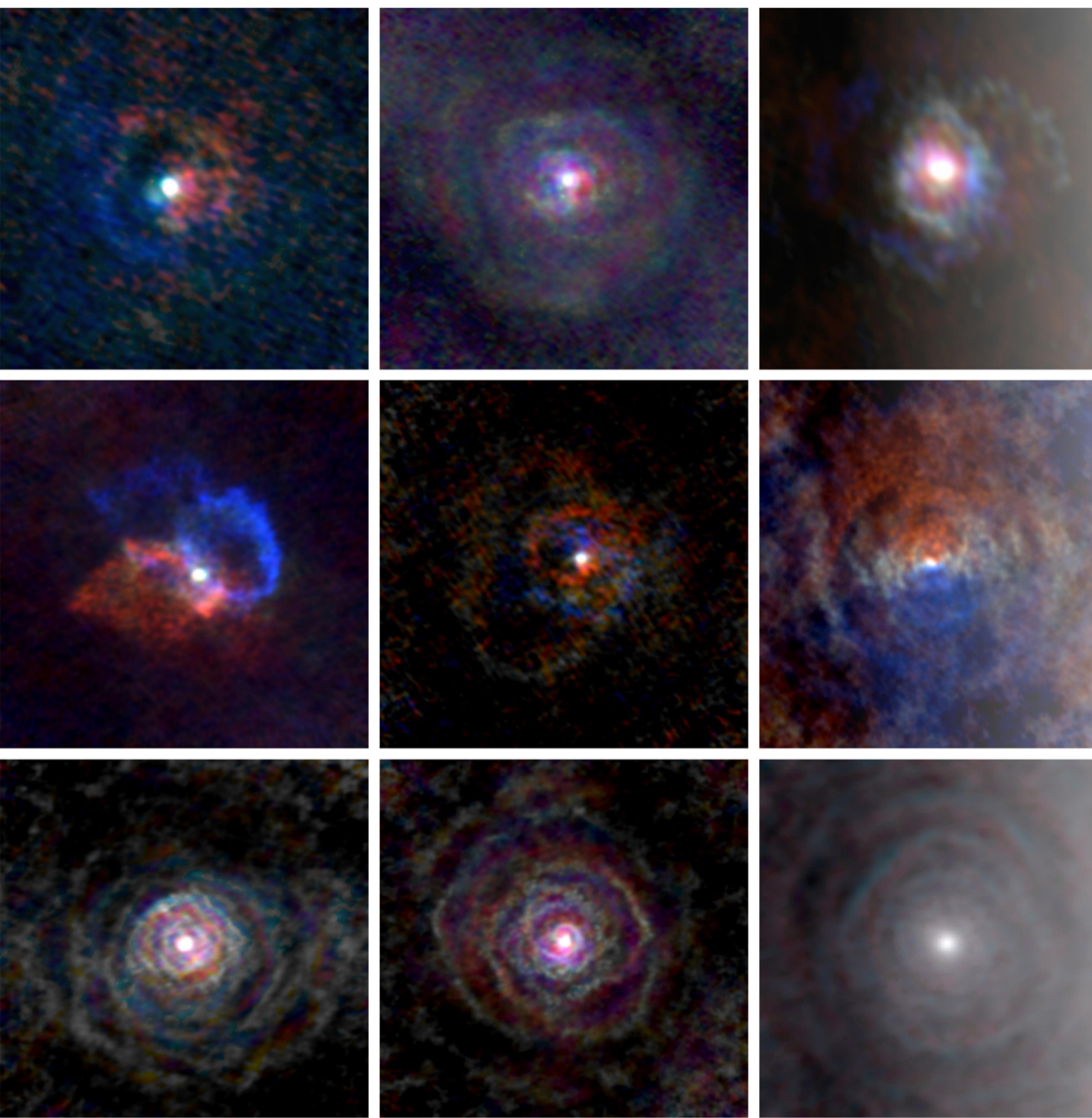
MEUDON (FRANCE)
<https://atomium23winter.sciencesconf.org>



Impact of different radiative transfer prescriptions on the morphological structures of AGB outflows

- **Mats Esseldeurs**
- 1st year PhD student
- Supervisor: Leen Decin
- mats.esseldeurs@kuleuven.be





- Goal
- Unravel impact of companion on wind structures and dynamics
 - Get better understanding of observations through simulations

Hydrodynamic setup

- 3D Smoothed Particle Hydrodynamics (SPH)
- Phantom by Price et al. (2018)



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wind

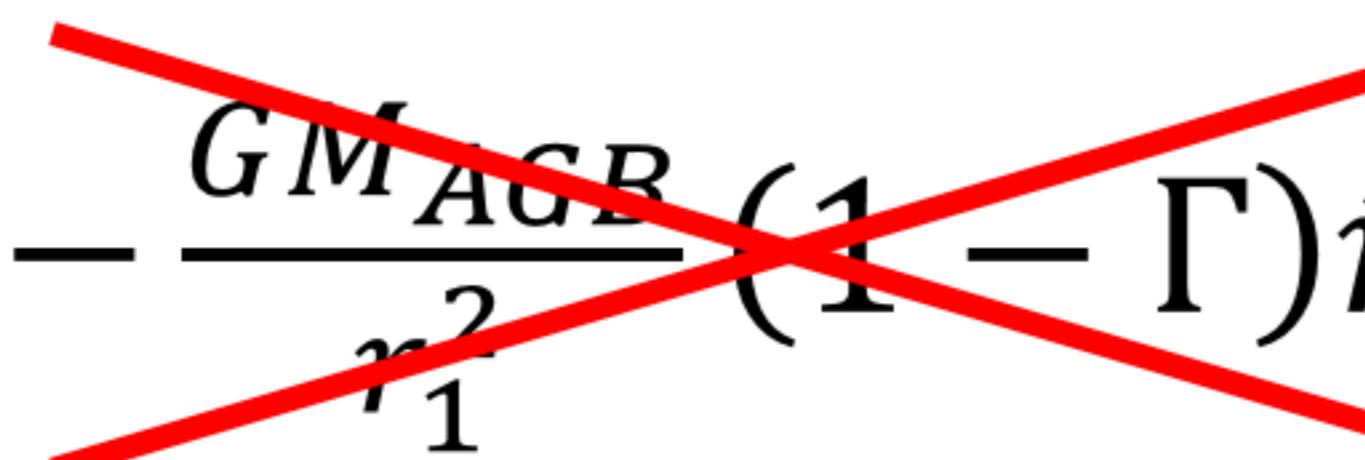
launching

Previous work: Free-wind approximation

- $\vec{a} = -\frac{GM_{AGB}}{r_1^2}(1 - \Gamma)\hat{r}_1 - \frac{GM_{comp}}{r_2^2}\hat{r}_2$

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THE ASTROPHYSICAL JOURNAL, 523:357–380, 1999 September 20
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BIPOLAR PRE-PLANETARY NEBULAE: HYDRODYNAMICS OF DUSTY WINDS IN BINARY SYSTEMS. II. MORPHOLOGY OF THE CIRCUMSTELLAR ENVELOPES

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SPH modelling of companion-perturbed AGB outflows including a new morphology classification scheme

S. Maes¹, W. Homan^{2,1}, J. Malfait¹, L. Siess², J. Bolte¹, F. De Ceuster^{3,1}, and L. Decin^{1,4}

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3D models of the circumstellar environments of evolved stars: Formation of multiple spiral structures

Elias Aydi^{1,2,3*} and Shazrene Mohamed^{2,3,4,5*}

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Formation of the Asymmetric Accretion Disk from Stellar Wind Accretion in an S-type Symbiotic Star

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² SEP Engineering, Anyang, Gyeonggi, 14059, Republic of Korea

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3D hydrodynamical simulations of wind mass transfer and angular-momentum loss in AGB binary systems

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Slowly, slowly in the wind

Astronomy
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CrossMark

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Improvements

- External accelerations

- $\vec{a} = -\frac{GM_{AGB}}{r_1^2}(1 - \Gamma)\hat{r}_1 - \frac{GM_{comp}}{r_2^2}\hat{r}_2$

- Eddington factor: radiative acceleration

- $\Gamma = \frac{\kappa F/c}{GM_{AGB}/r_1^2}$

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- $\kappa(T_{eq}) = \frac{\kappa_{max}}{1 + exp[(T_{eq} - T_{cond})/\delta]} + \kappa_g$

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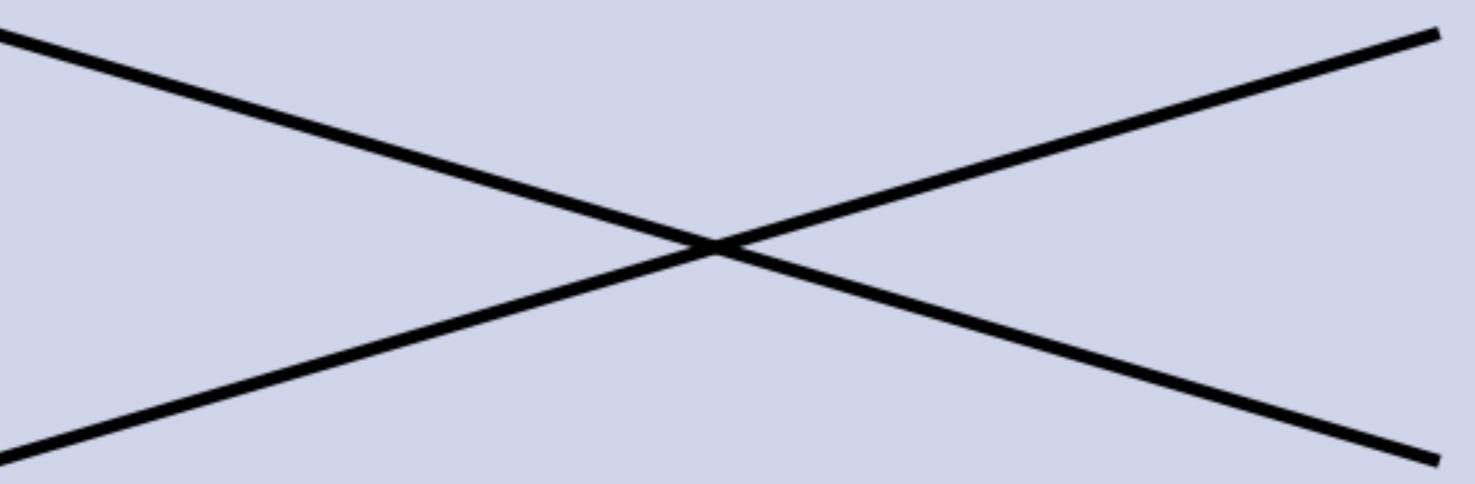
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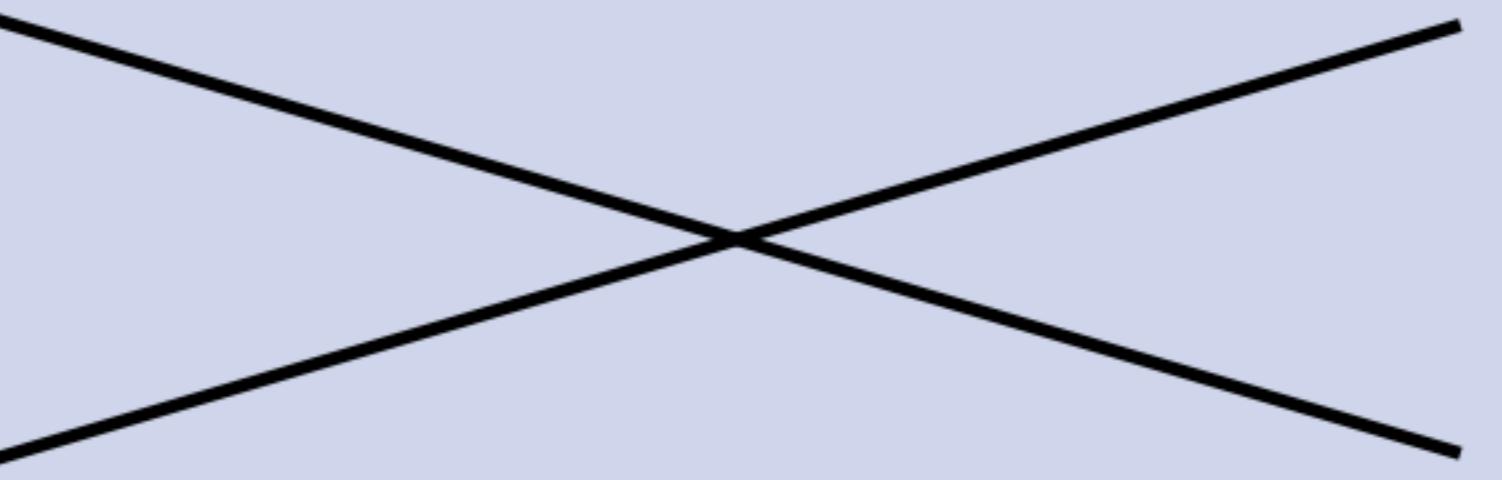
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Approximations

Approximations	Γ	T_{eq}
Free-wind	$\Gamma = 1$	

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Geometrical	$\Gamma = \frac{\kappa L_{AGB}}{4\pi c G M_{AGB}}$	$T_{eq}^4 = \frac{1}{2} \left(1 - \sqrt{1 - \left(\frac{R_\star}{r} \right)^2} \right) T_\star^4$

Approximations

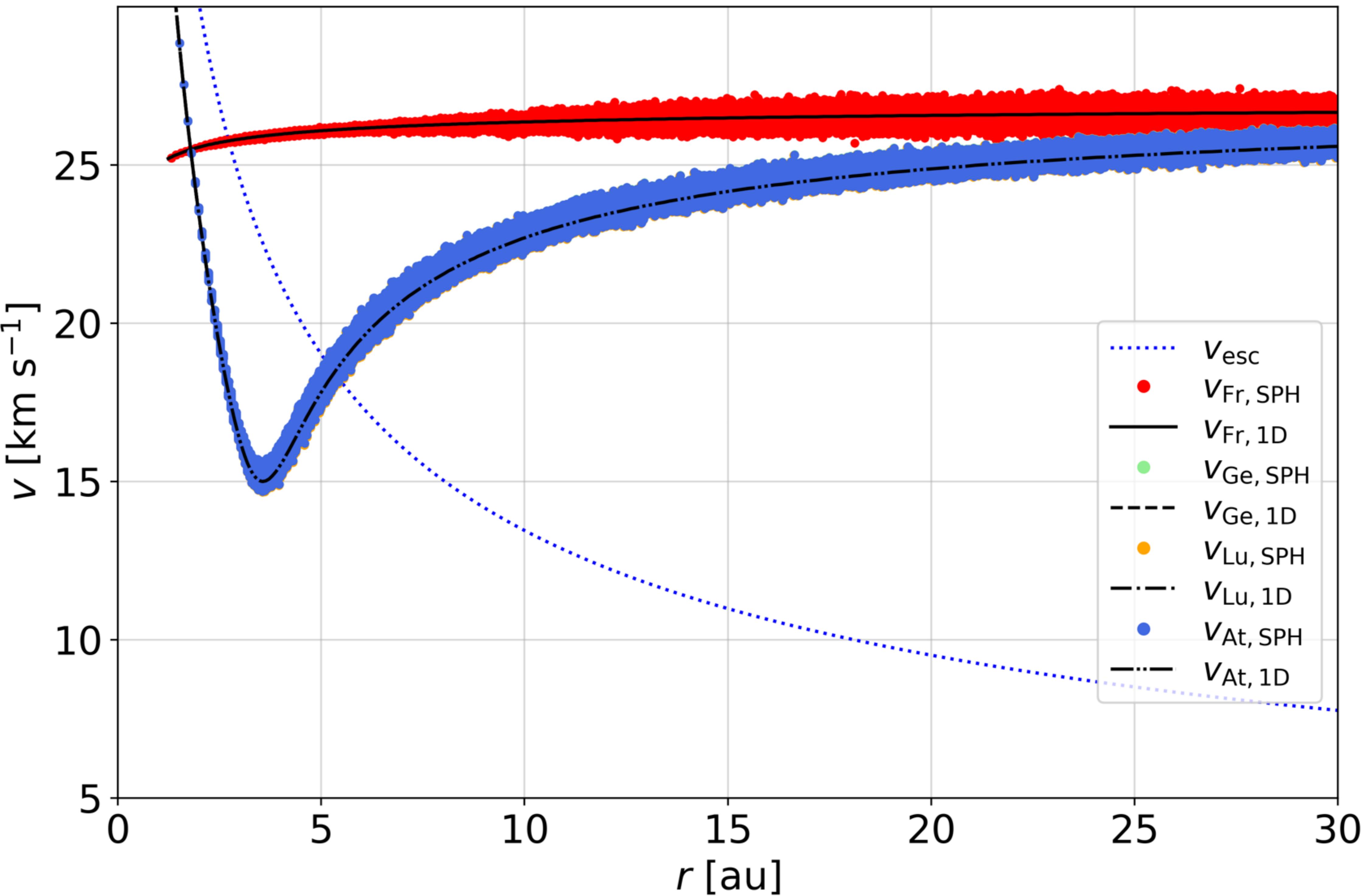
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Attenuation	$\Gamma = \frac{\kappa L_{AGB}}{4\pi c G M_{AGB}} e^{-\tau}$	$T_{eq}^4 = \frac{1}{2} \left(1 - \sqrt{1 - \left(\frac{R_\star}{r} \right)^2} \right) e^{-\tau} T_\star^4$

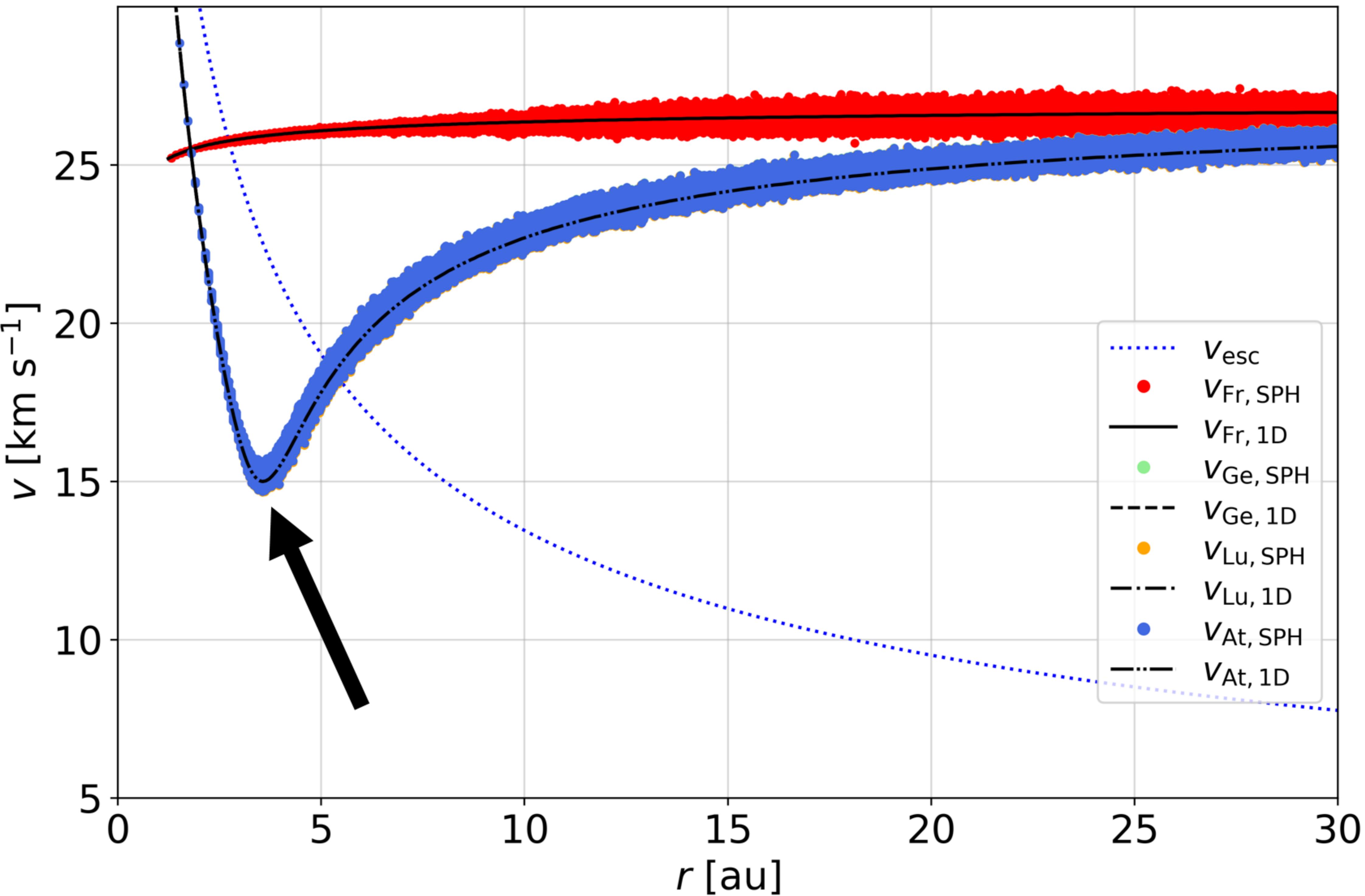
Velocity profile

Parameter	Value	Unit
\dot{M}_{AGB}	10^{-8} or 3×10^{-6}	$M_{\odot} \text{ yr}^{-1}$
M_{AGB}	1.02	M_{\odot}
L_{AGB}	4384	L_{\odot}
$T_{\text{eff,AGB}}$	2874	K
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R_{inj}	1.24	au
v_{inj}	33 or 25.2	km s^{-1}
γ	1.2	
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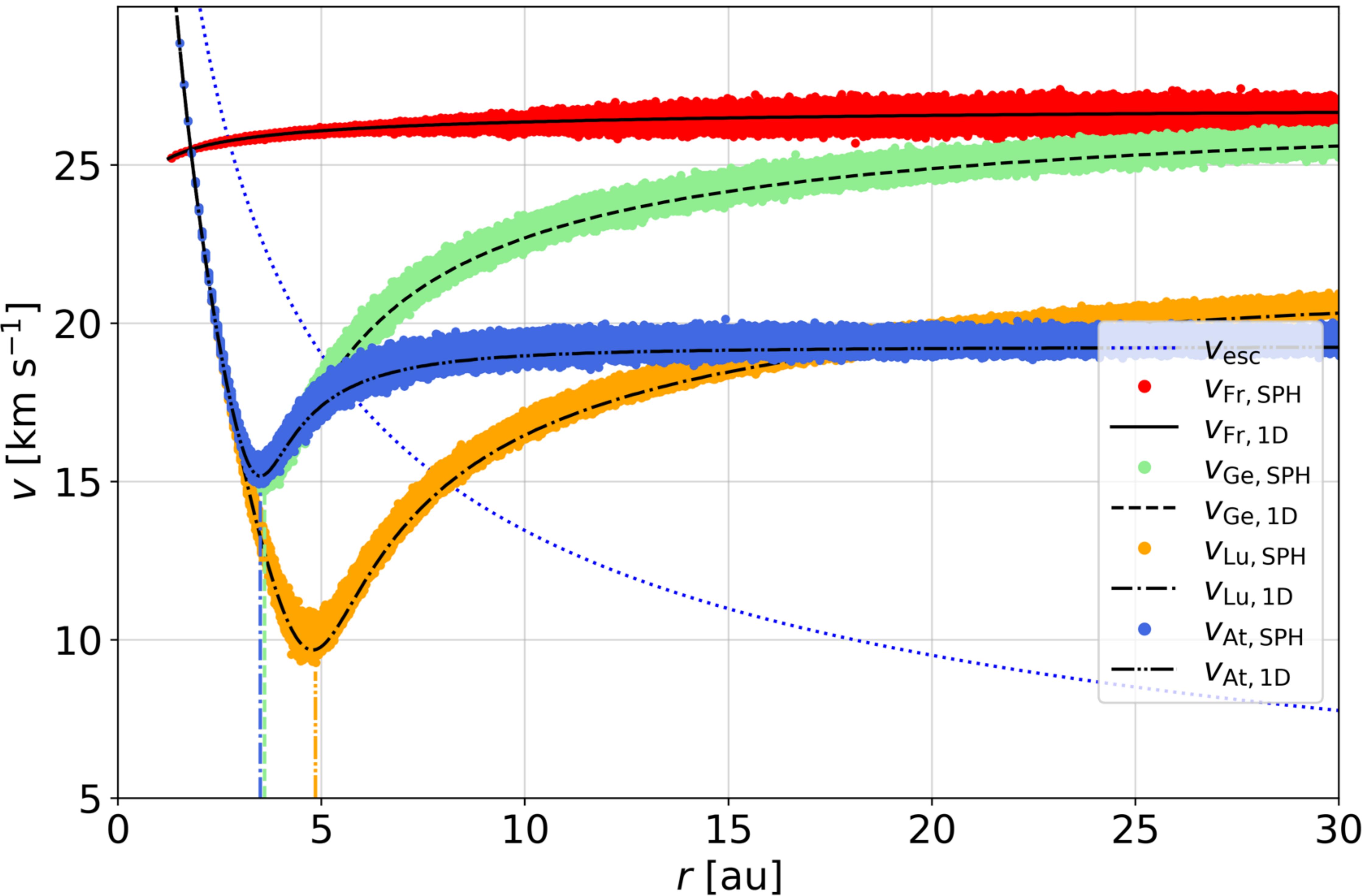
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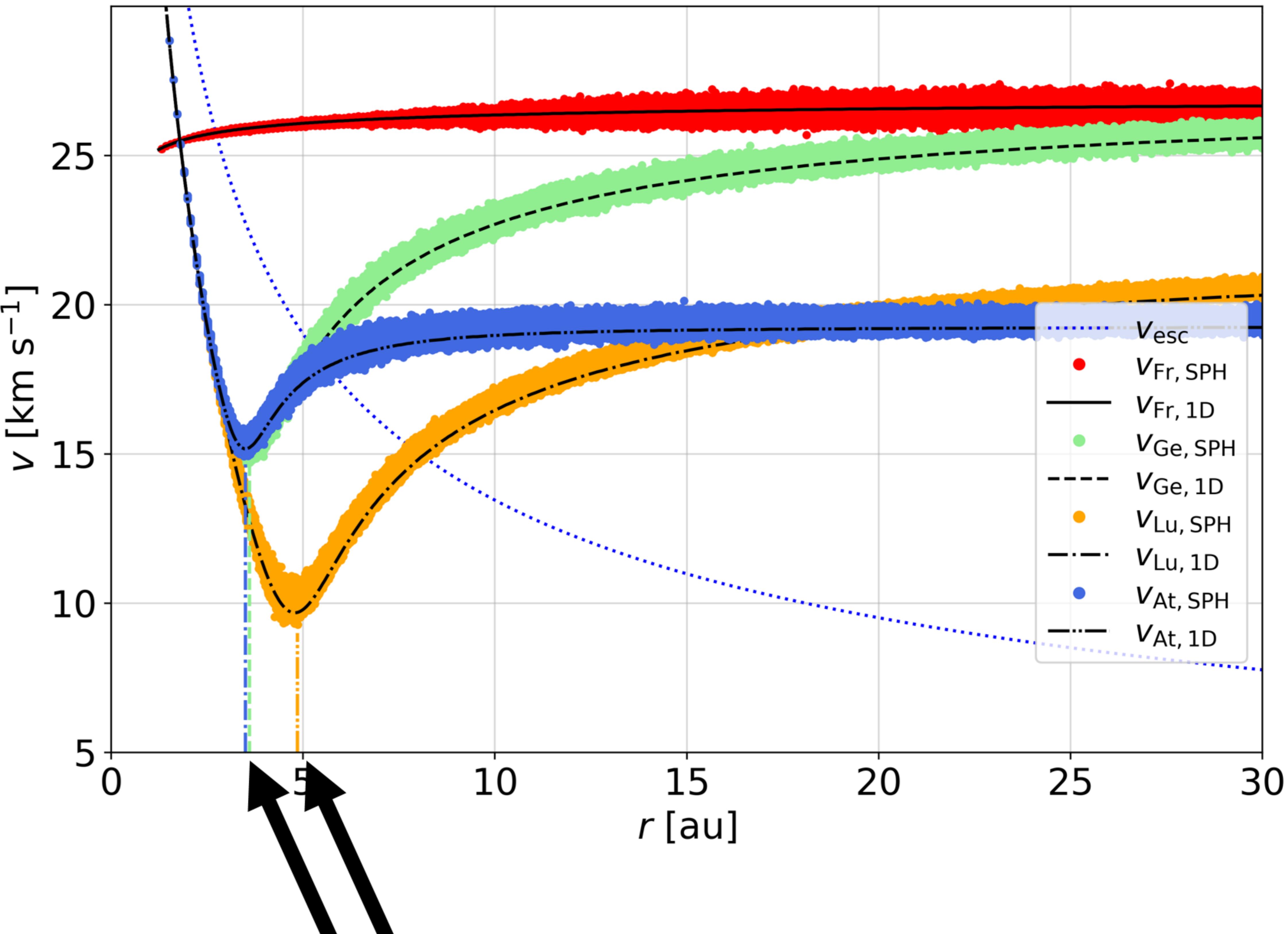
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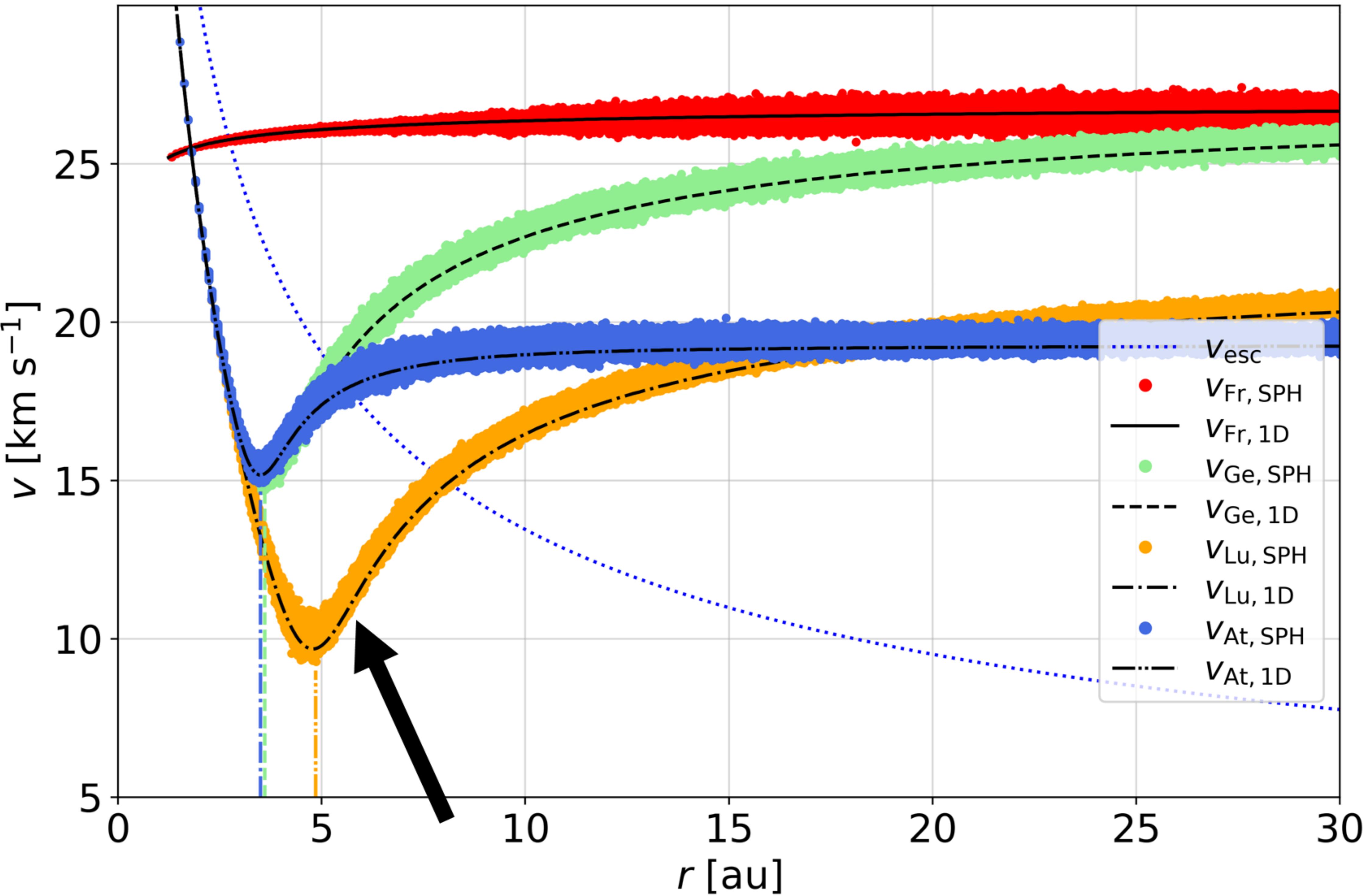
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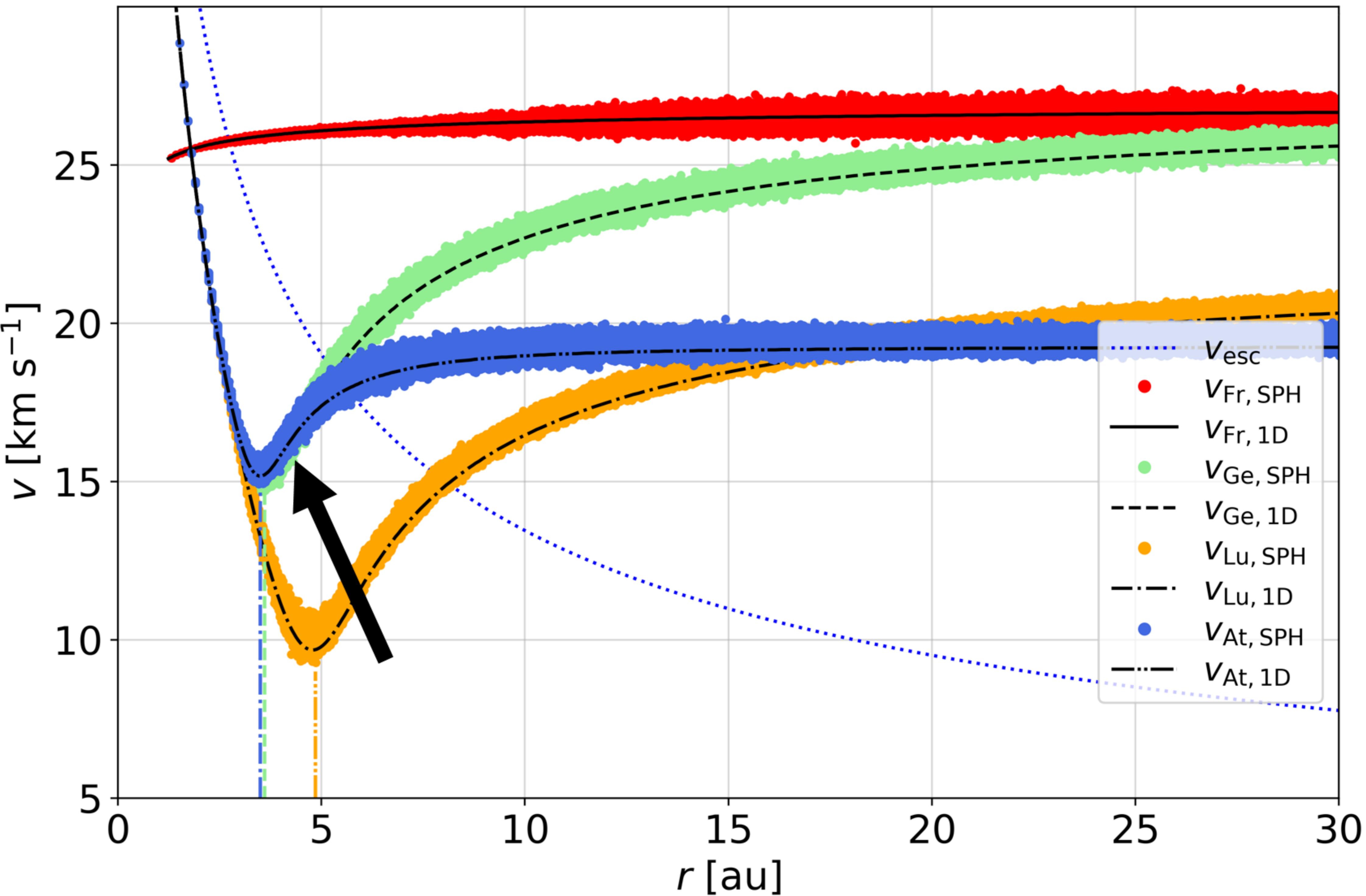
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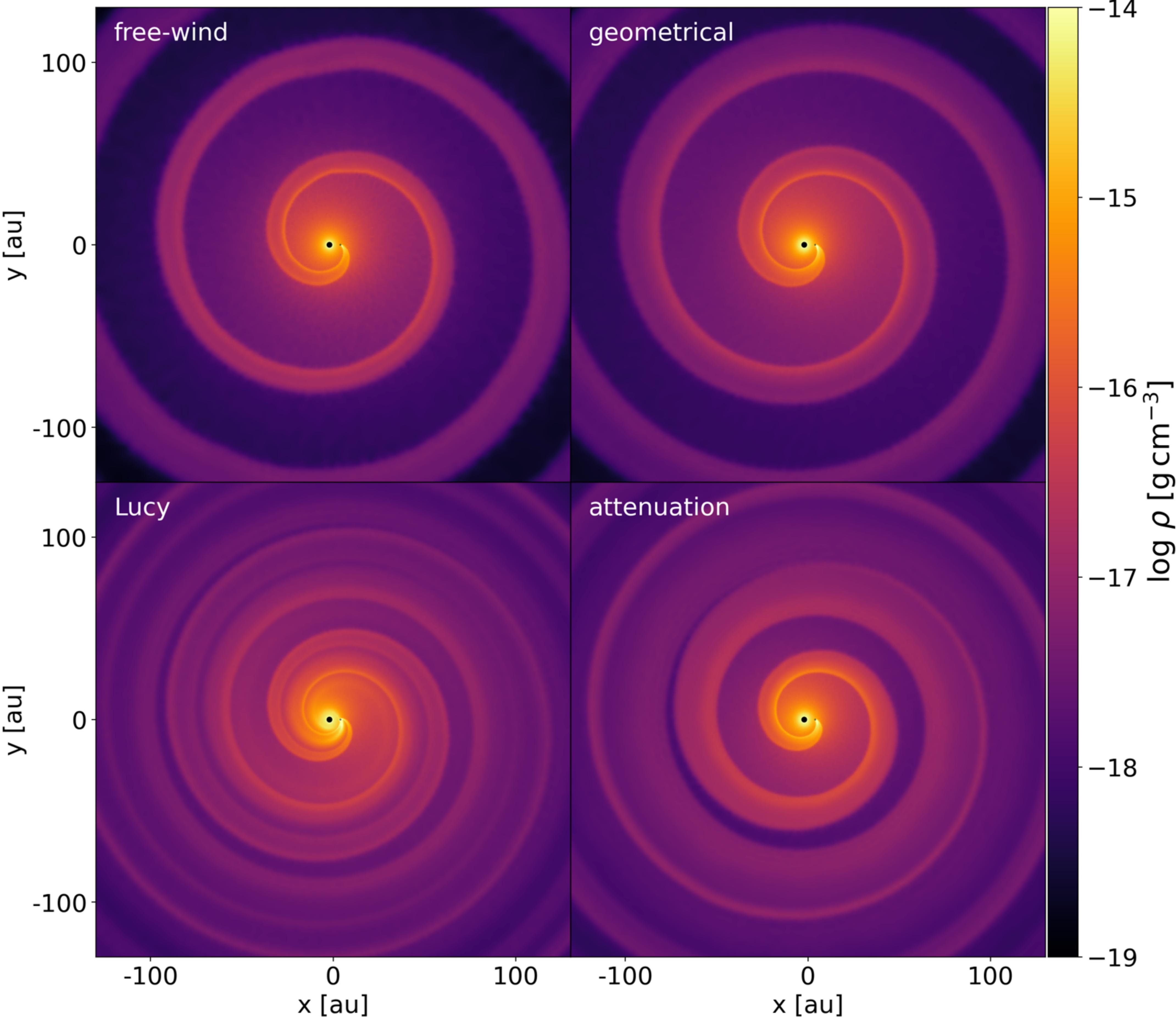
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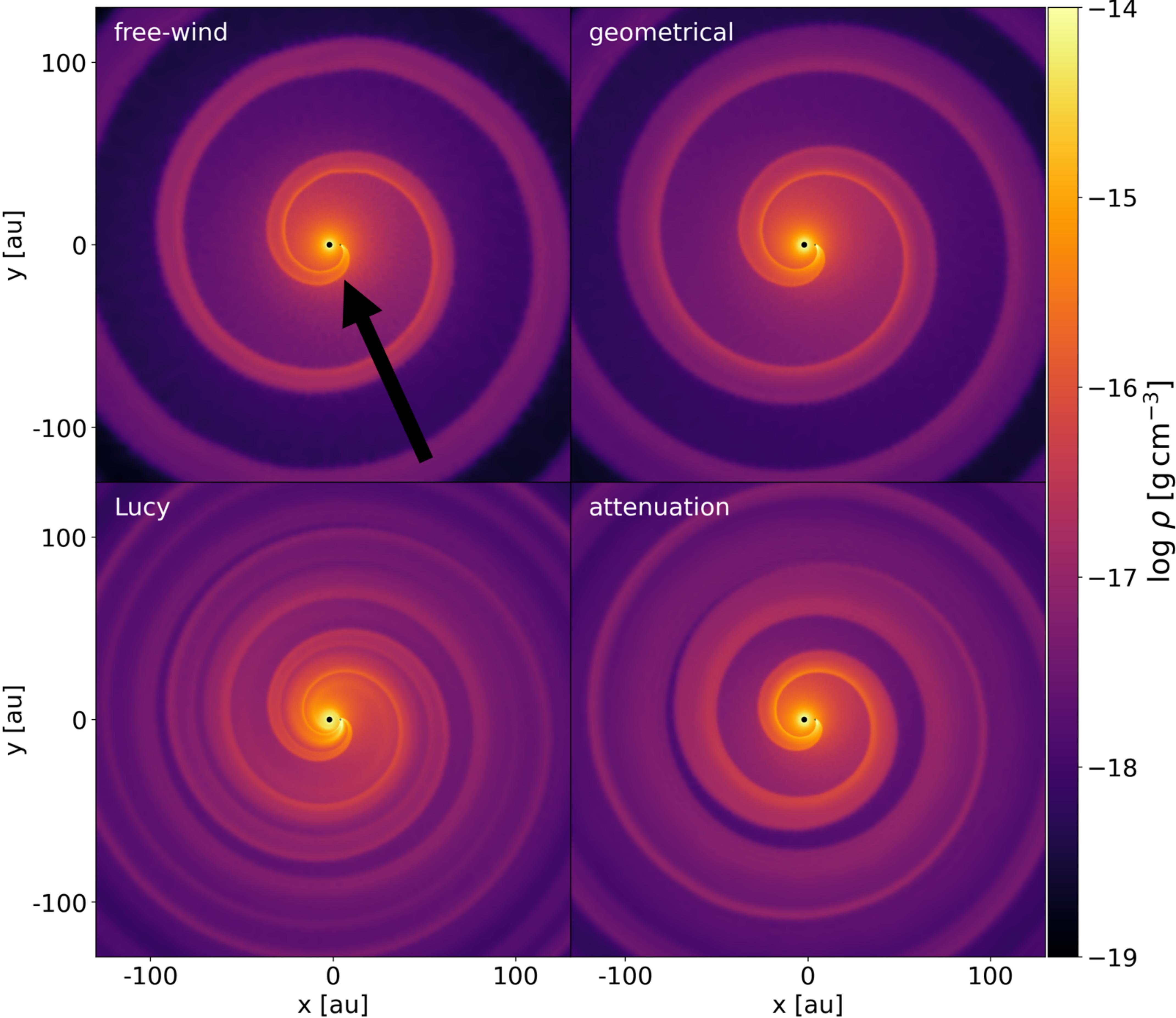
Morphological structures

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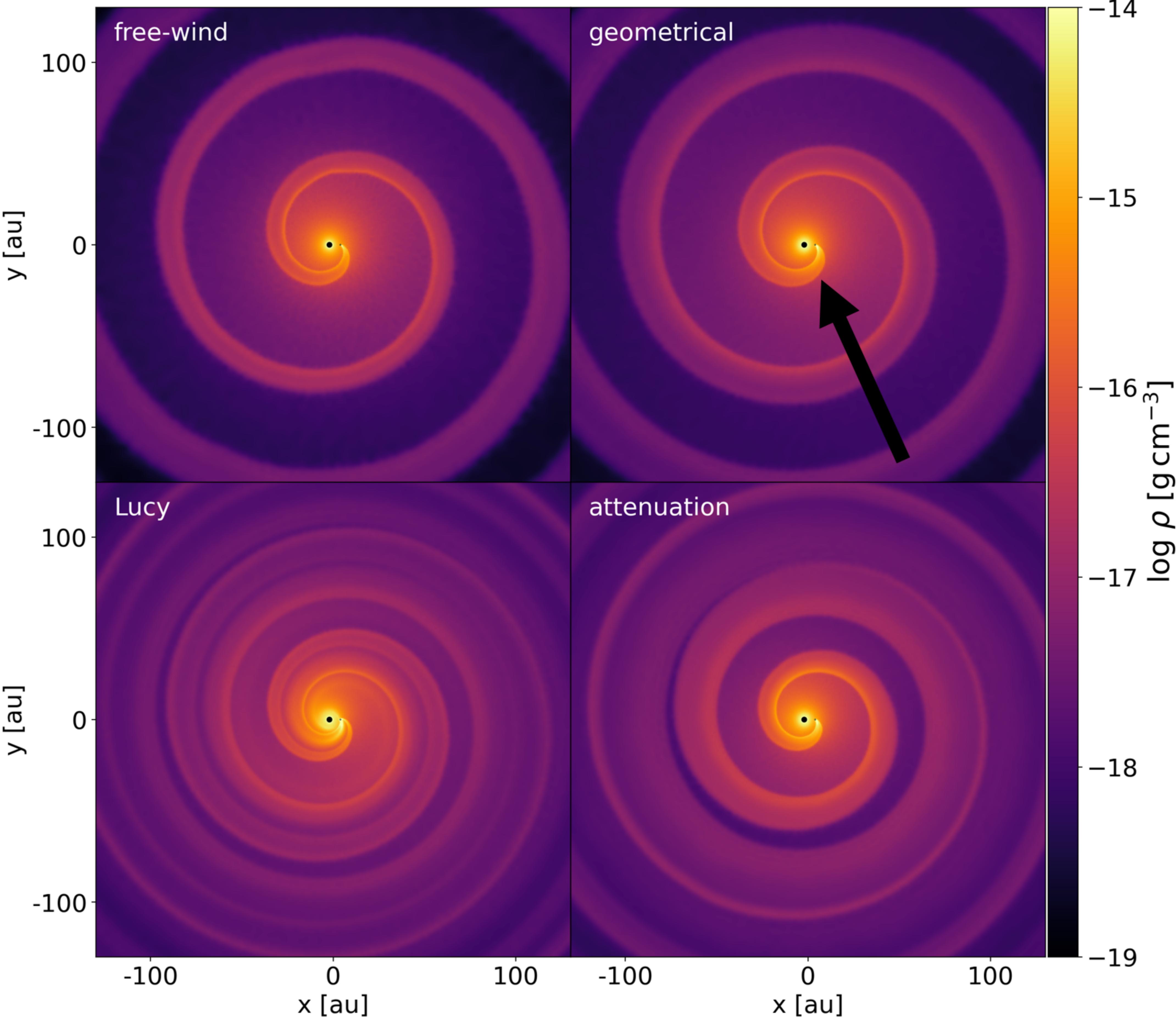
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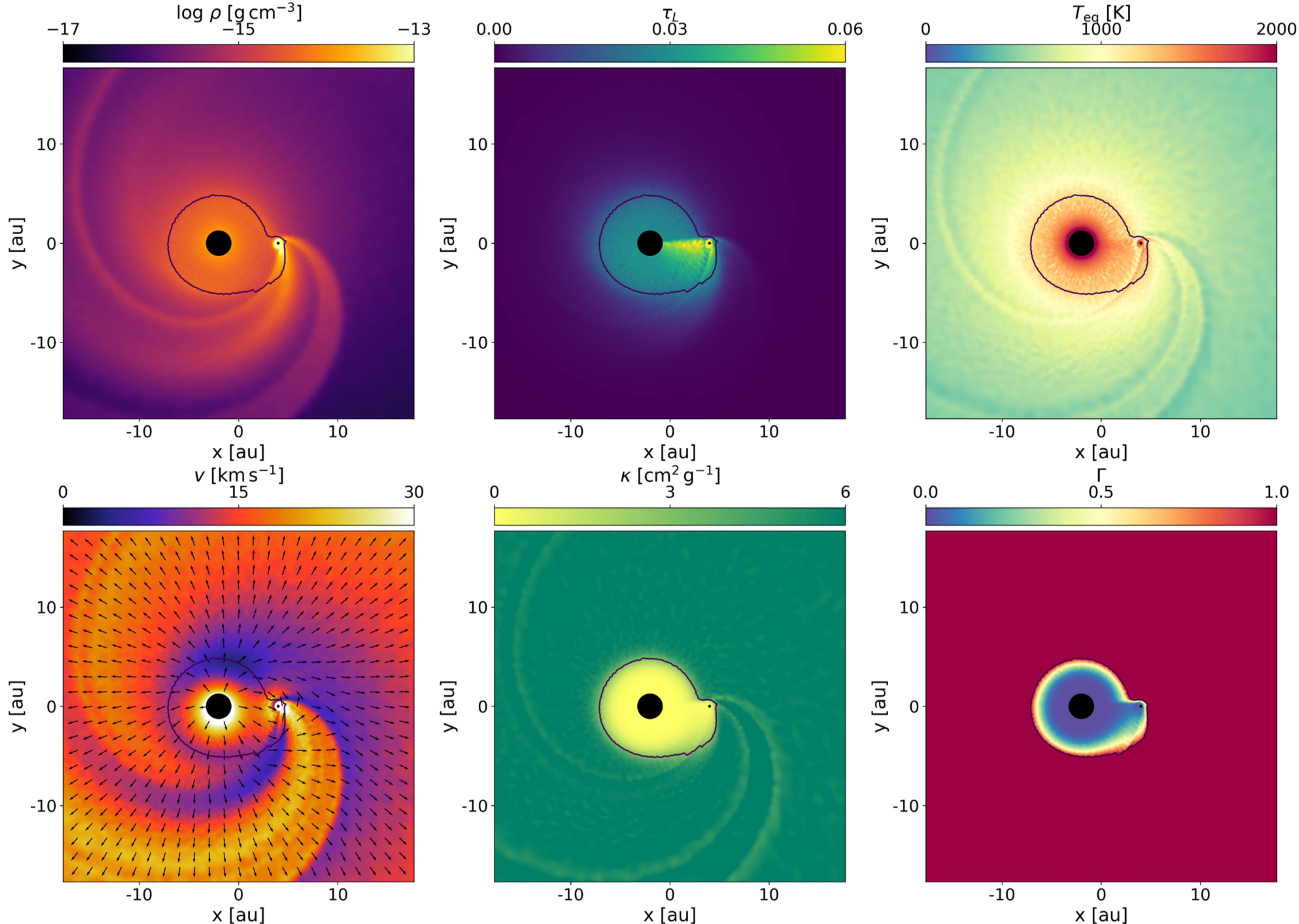


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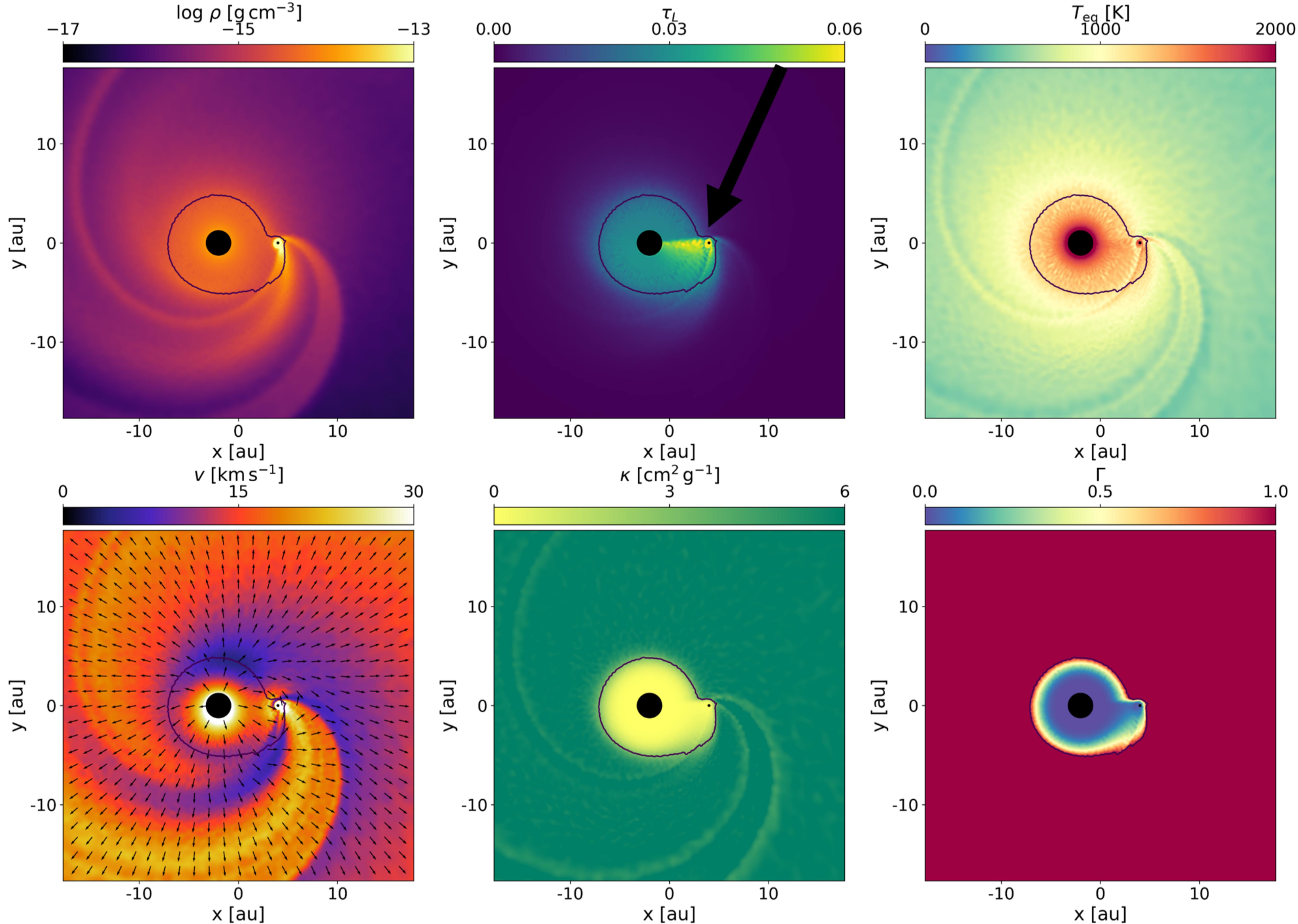
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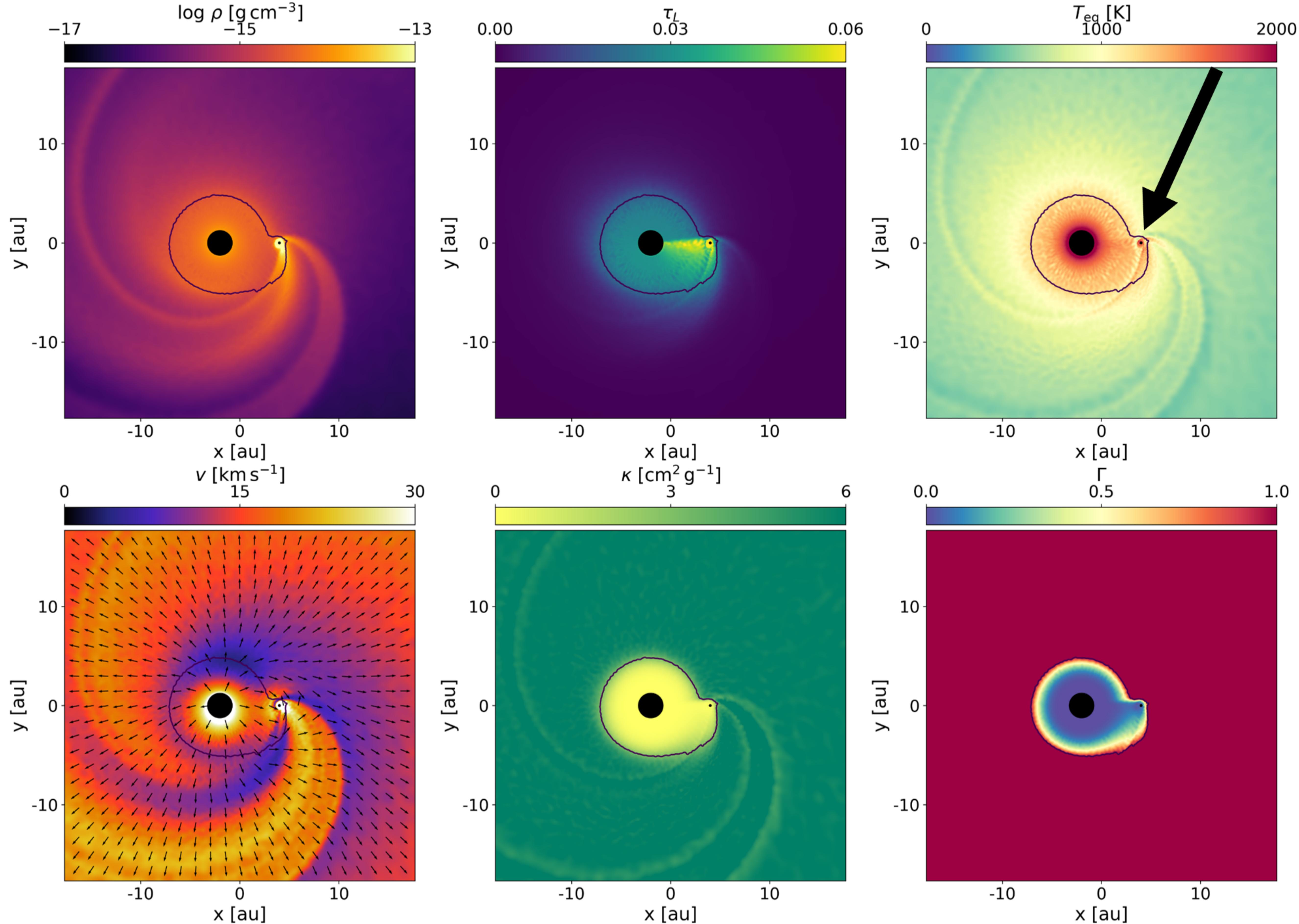
Lucy Approximation



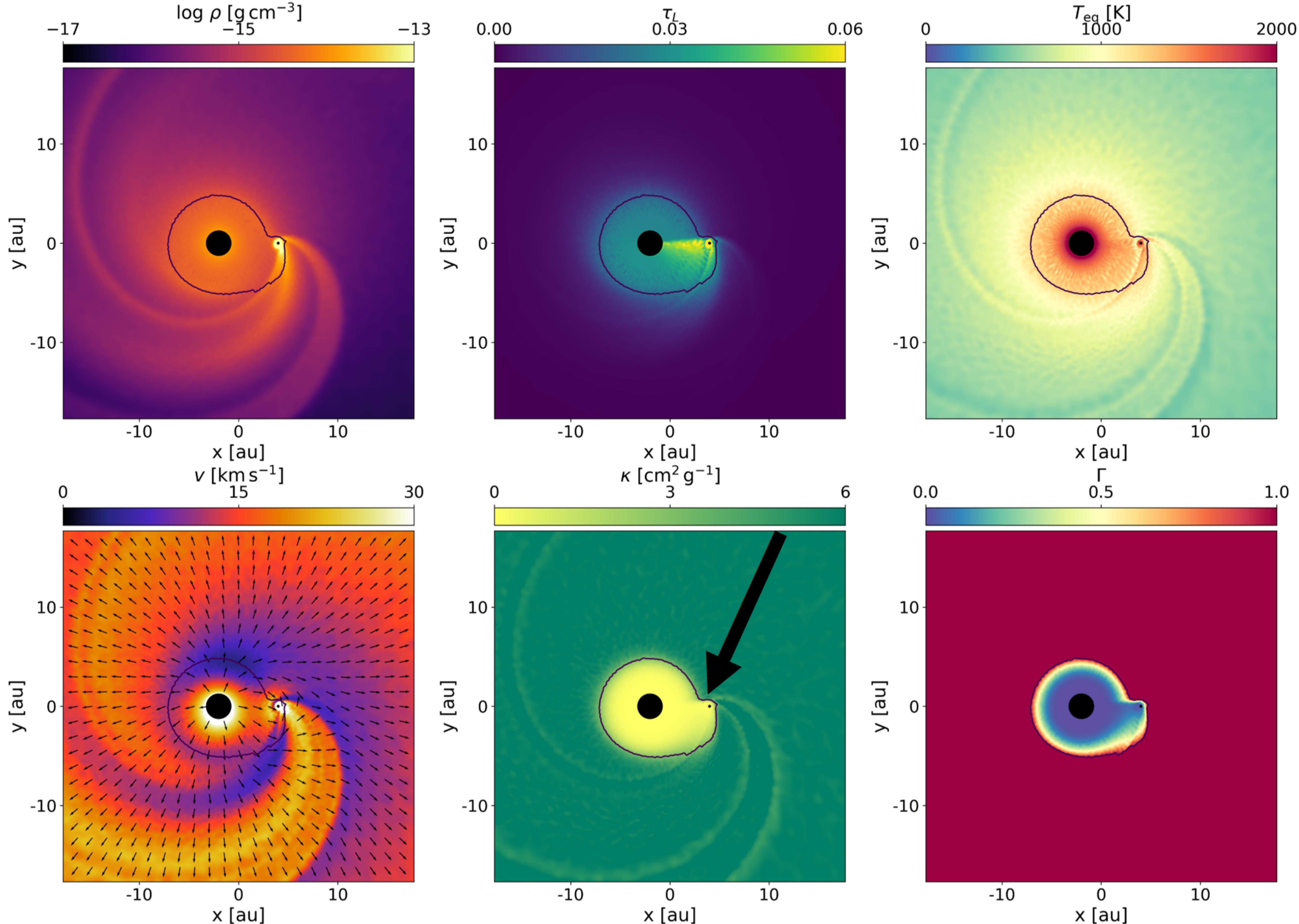
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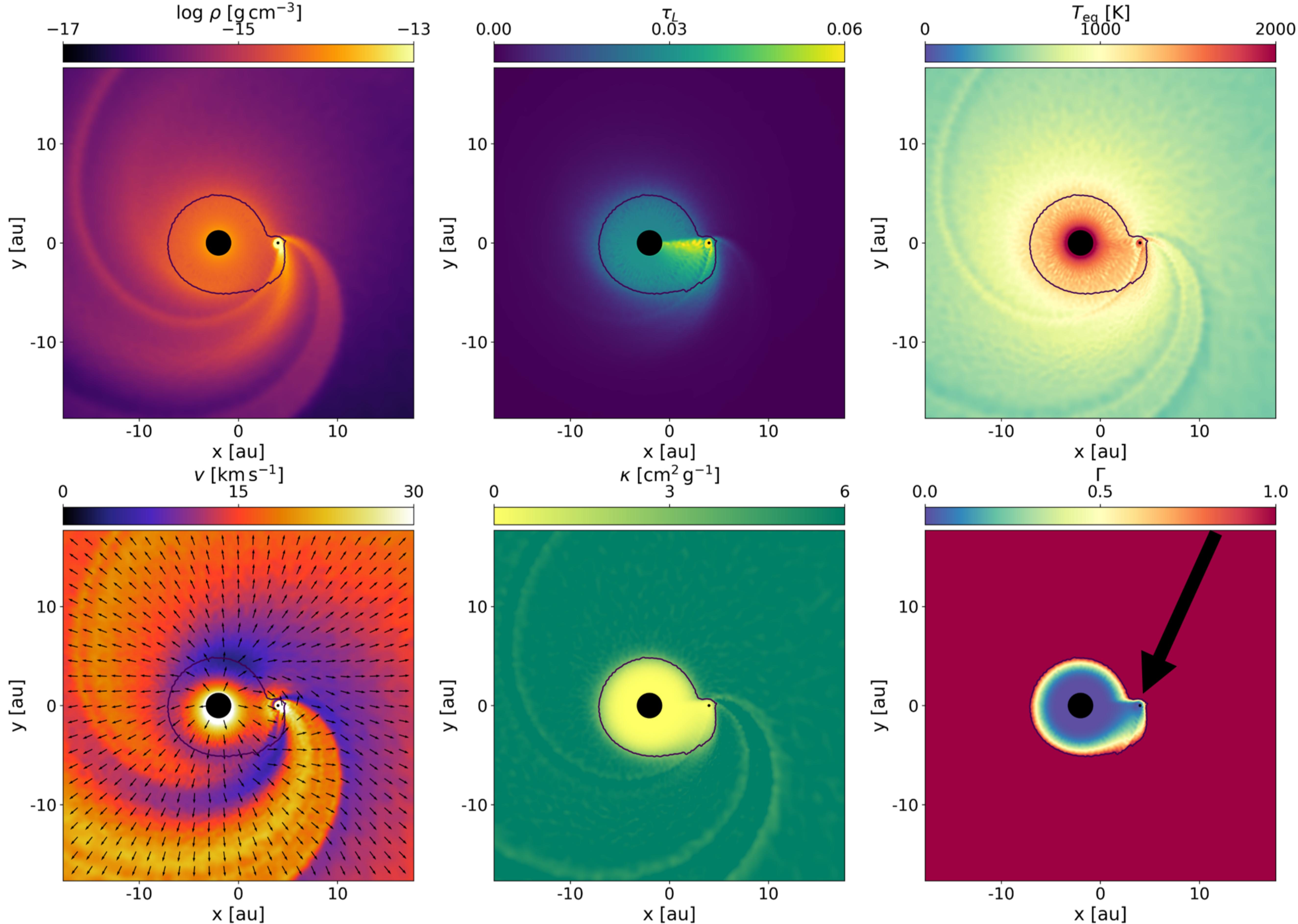
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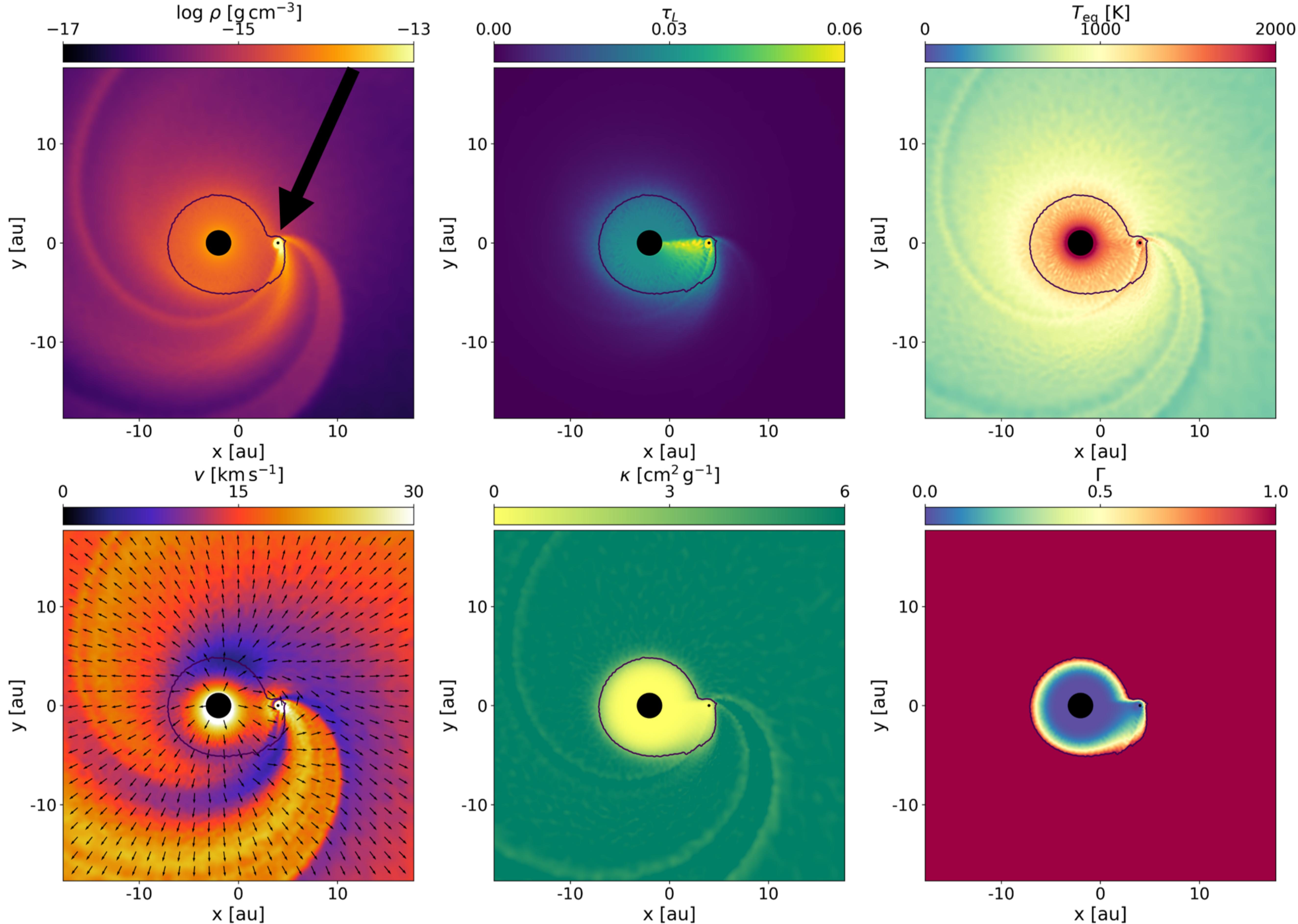
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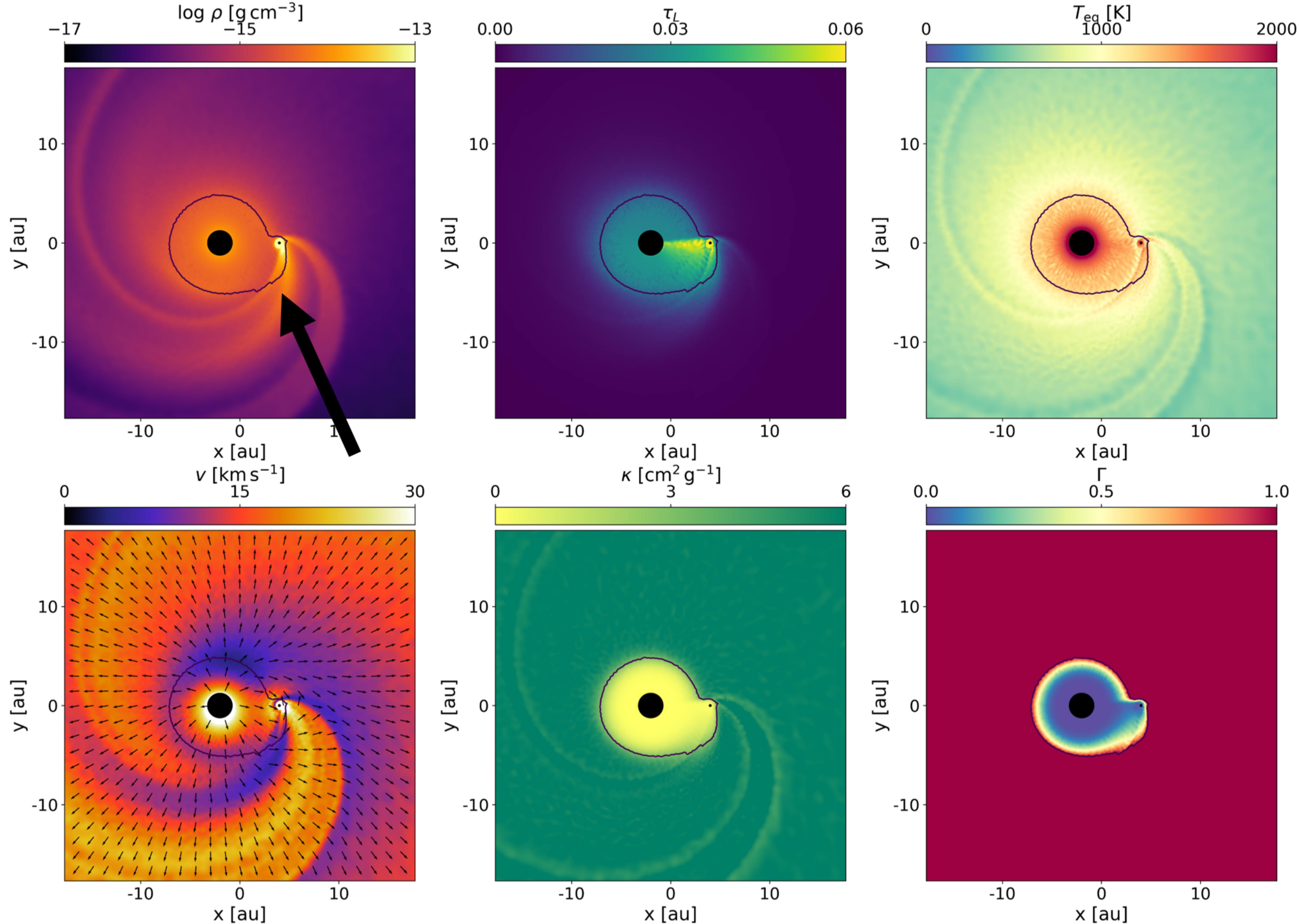
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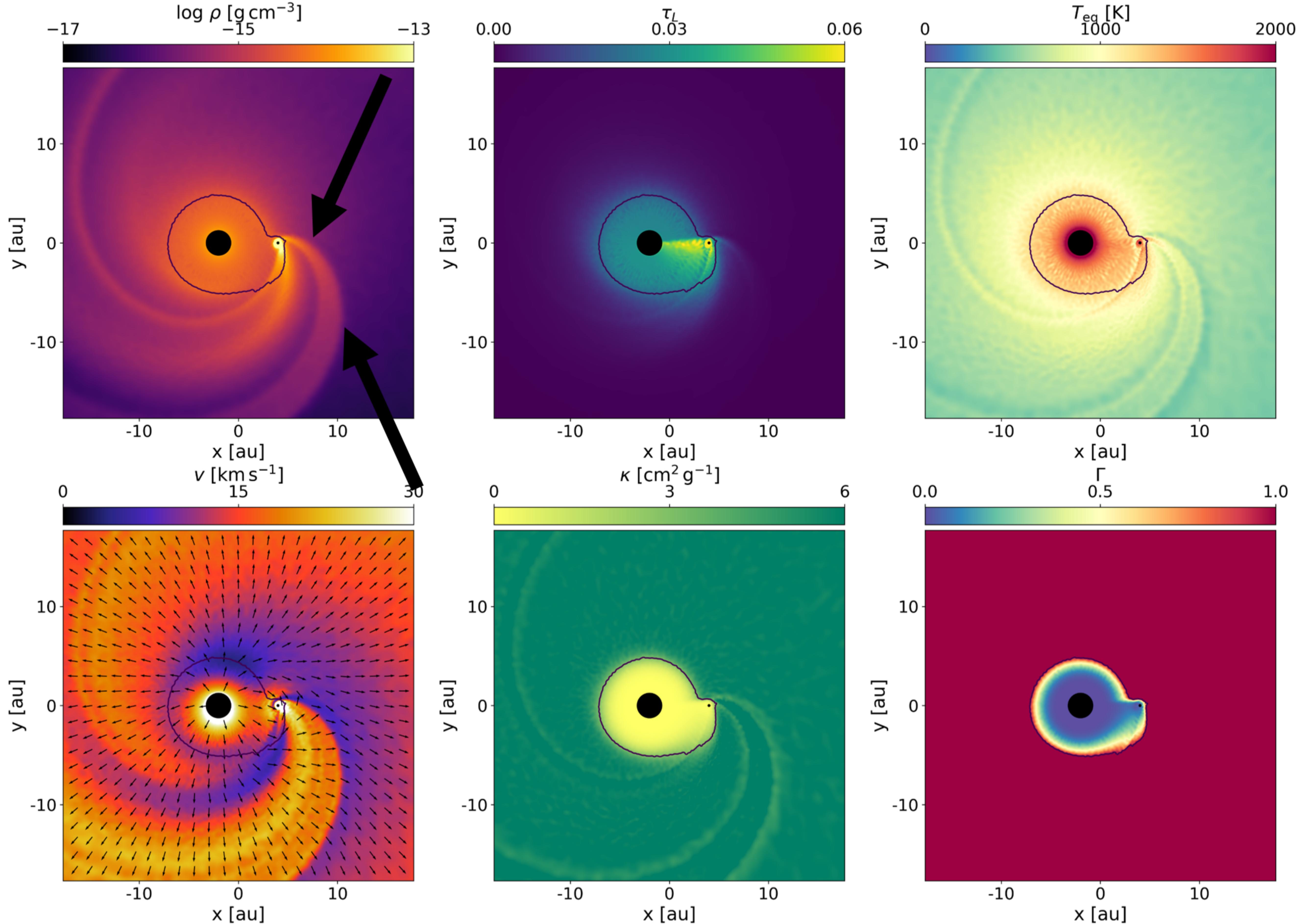
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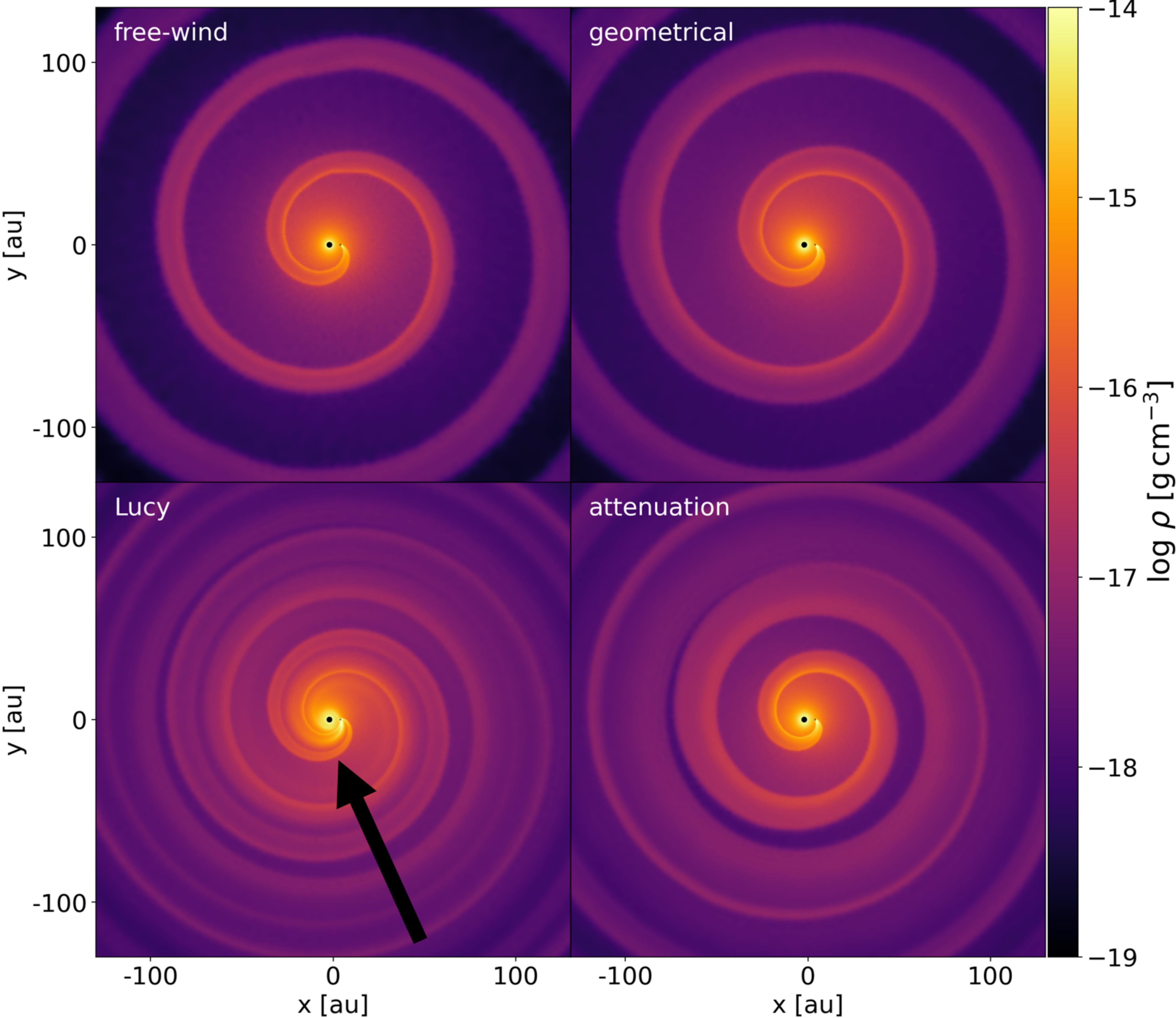


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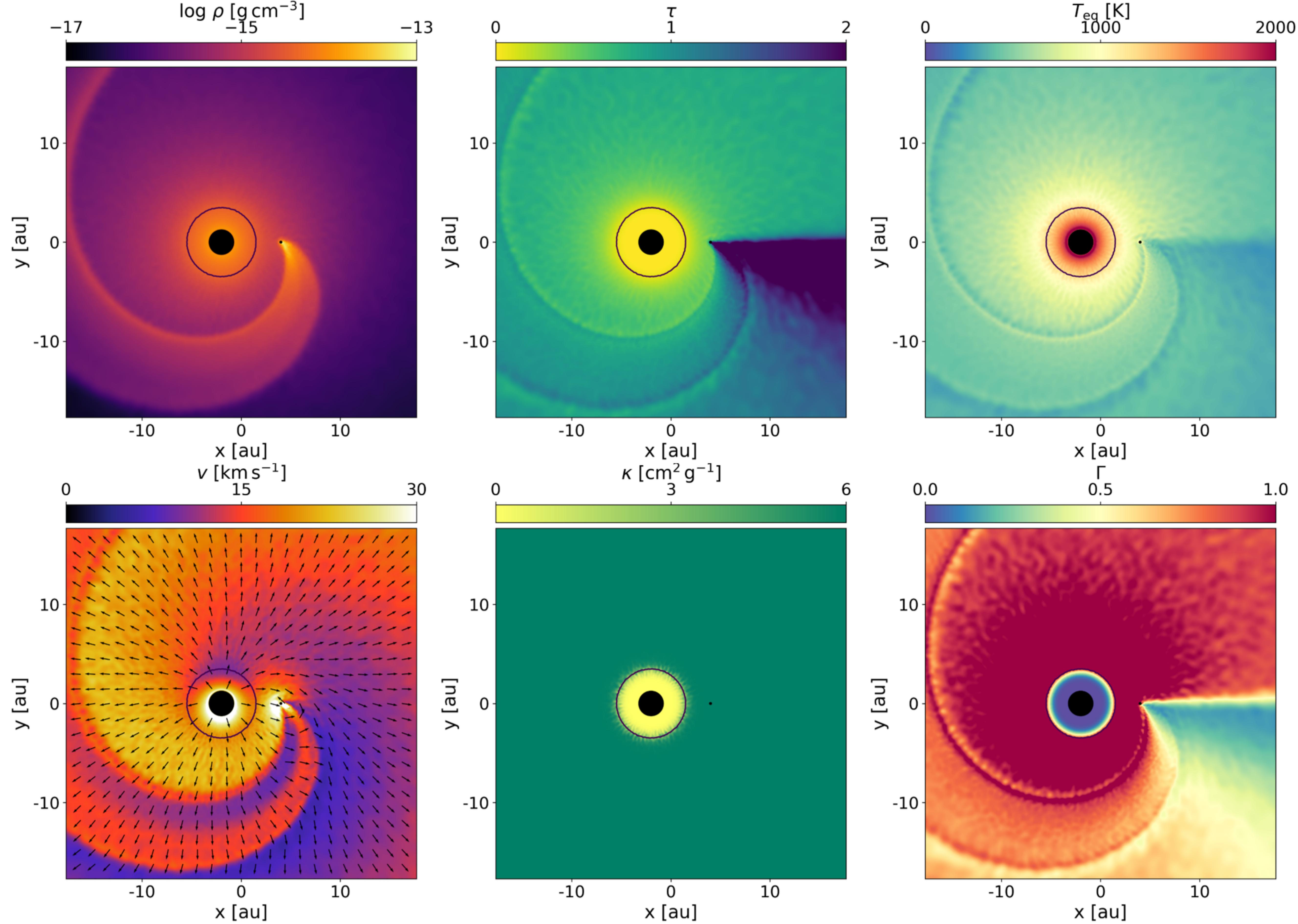


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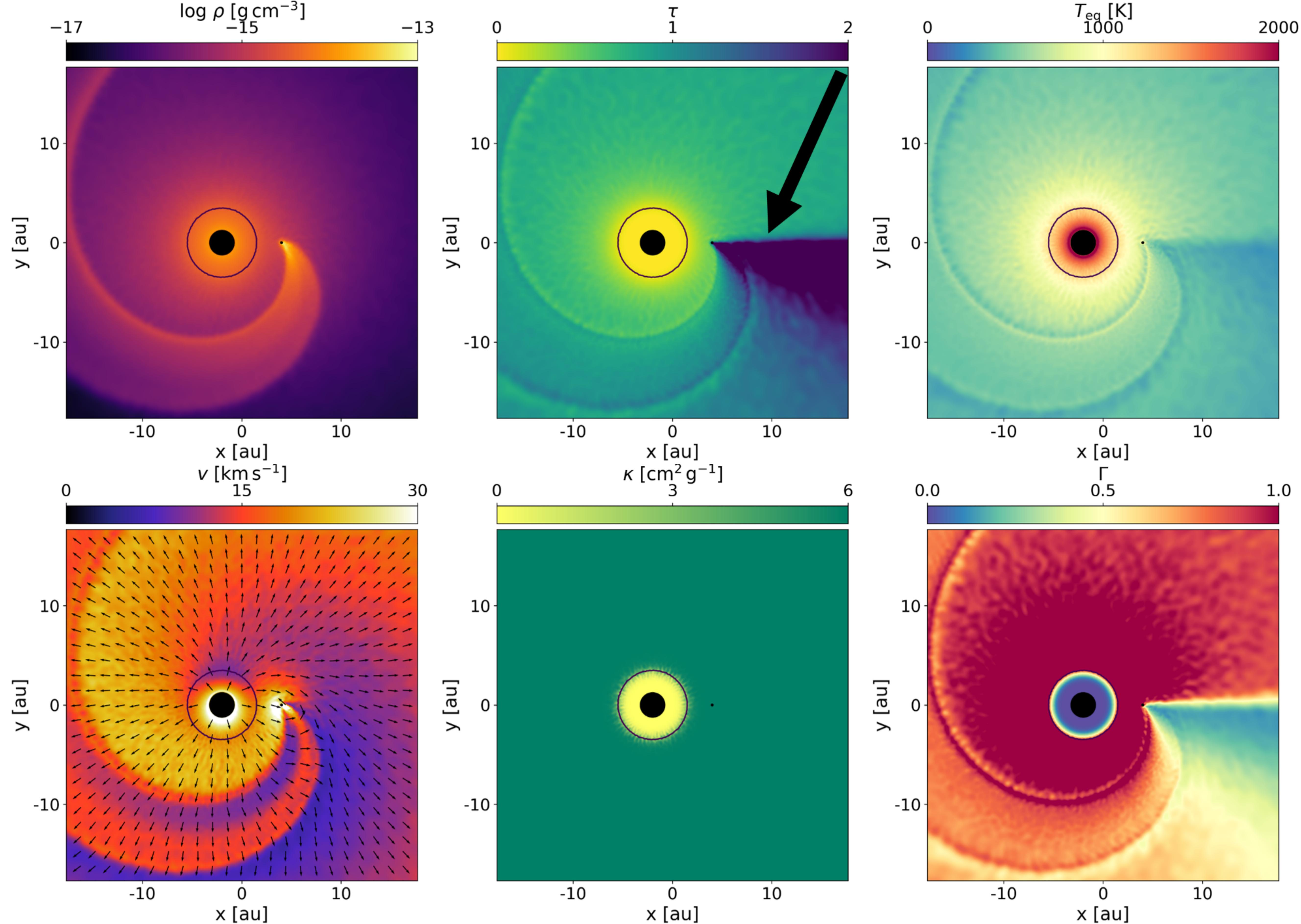
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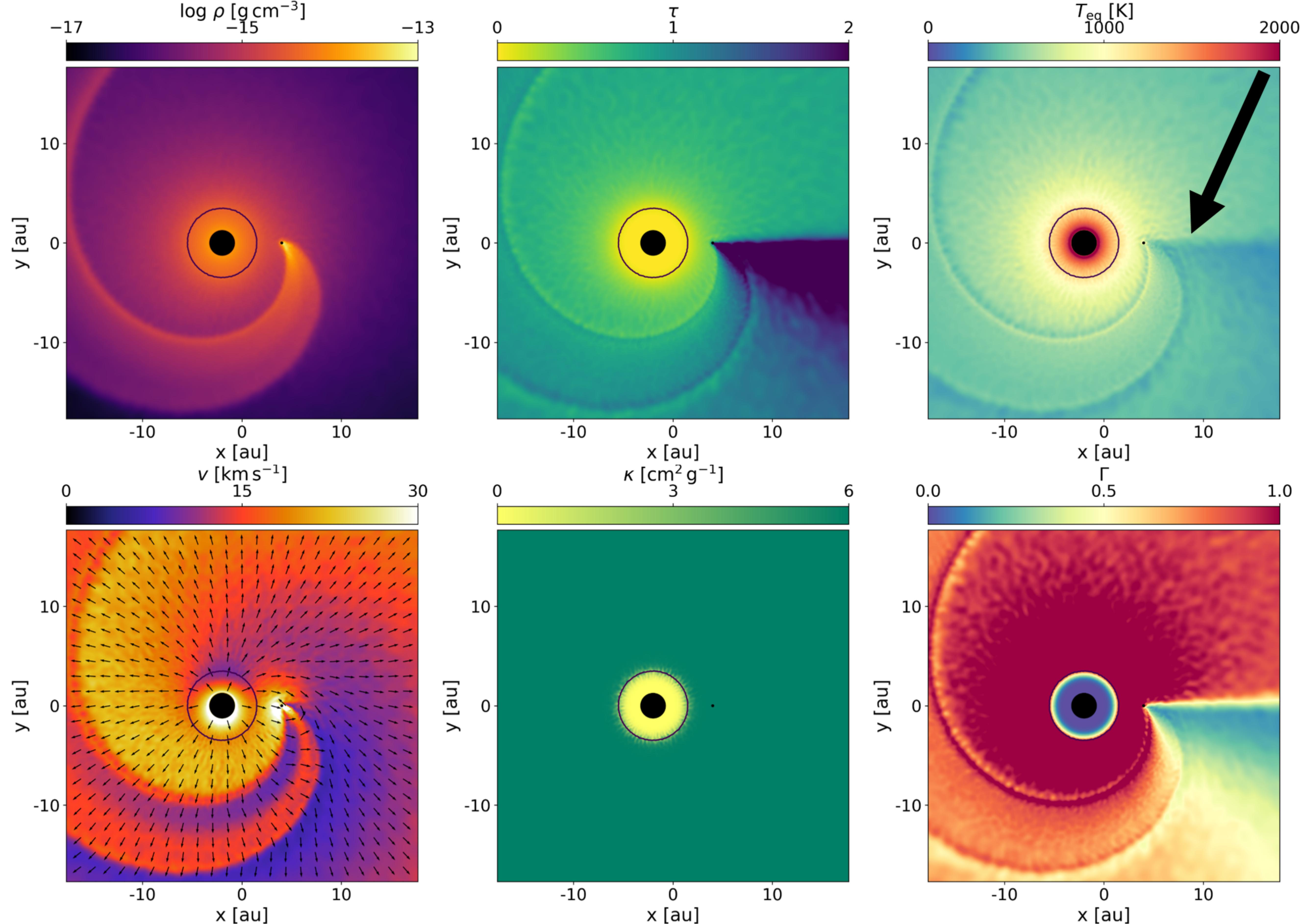
Attenuation Approximation



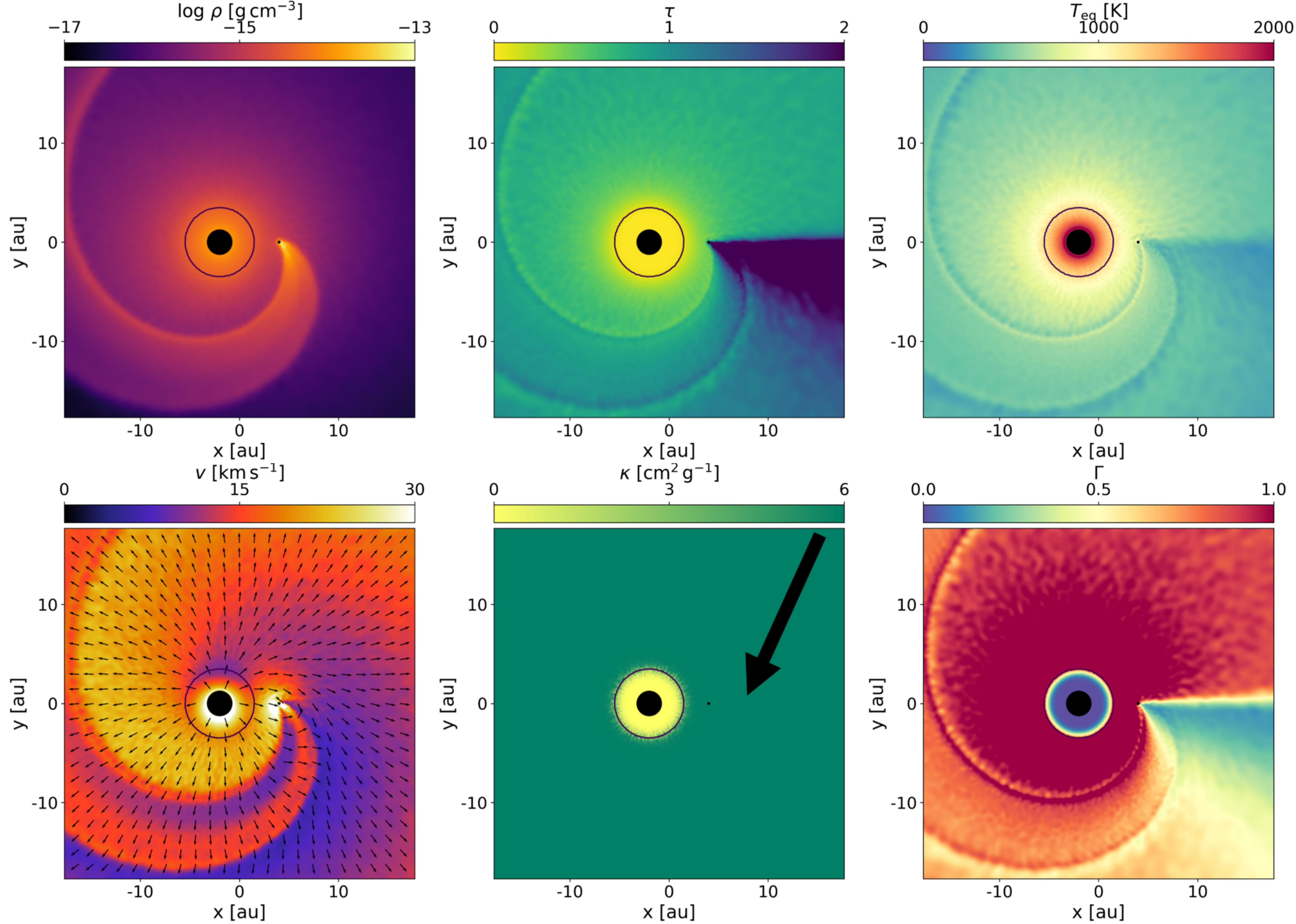
Attenuation Approximation



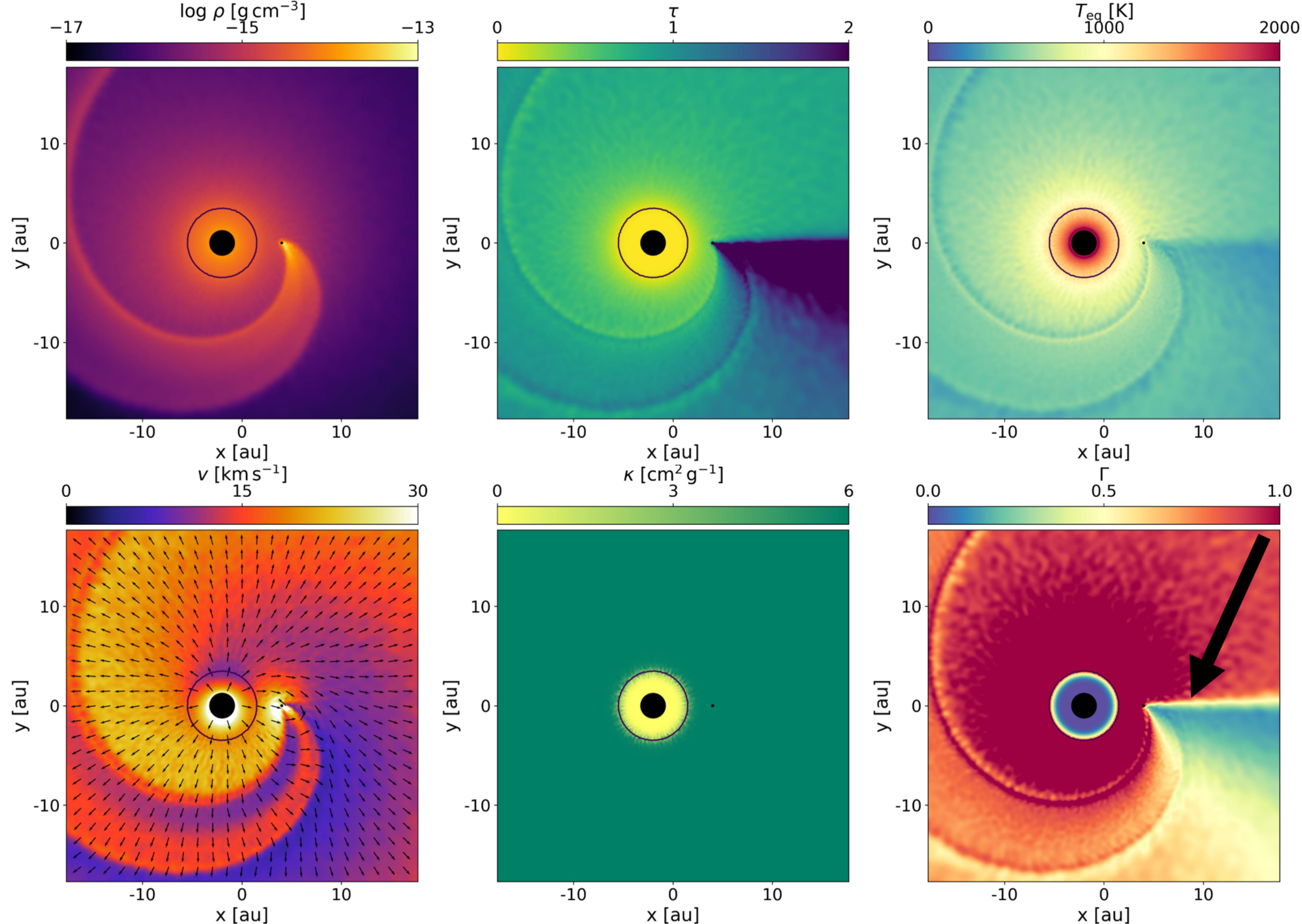
Attenuation Approximation



Attenuation Approximation

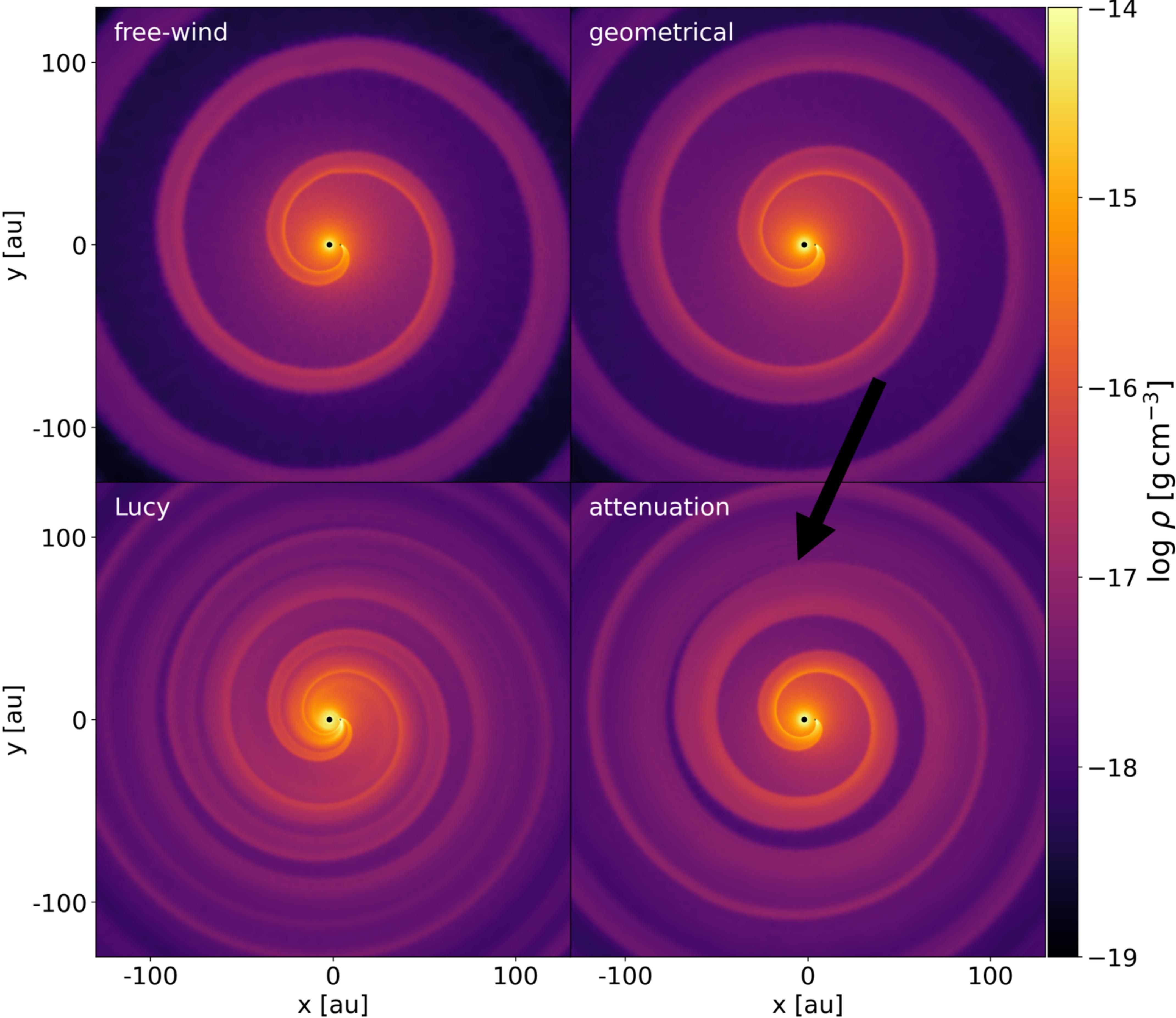


Attenuation Approximation



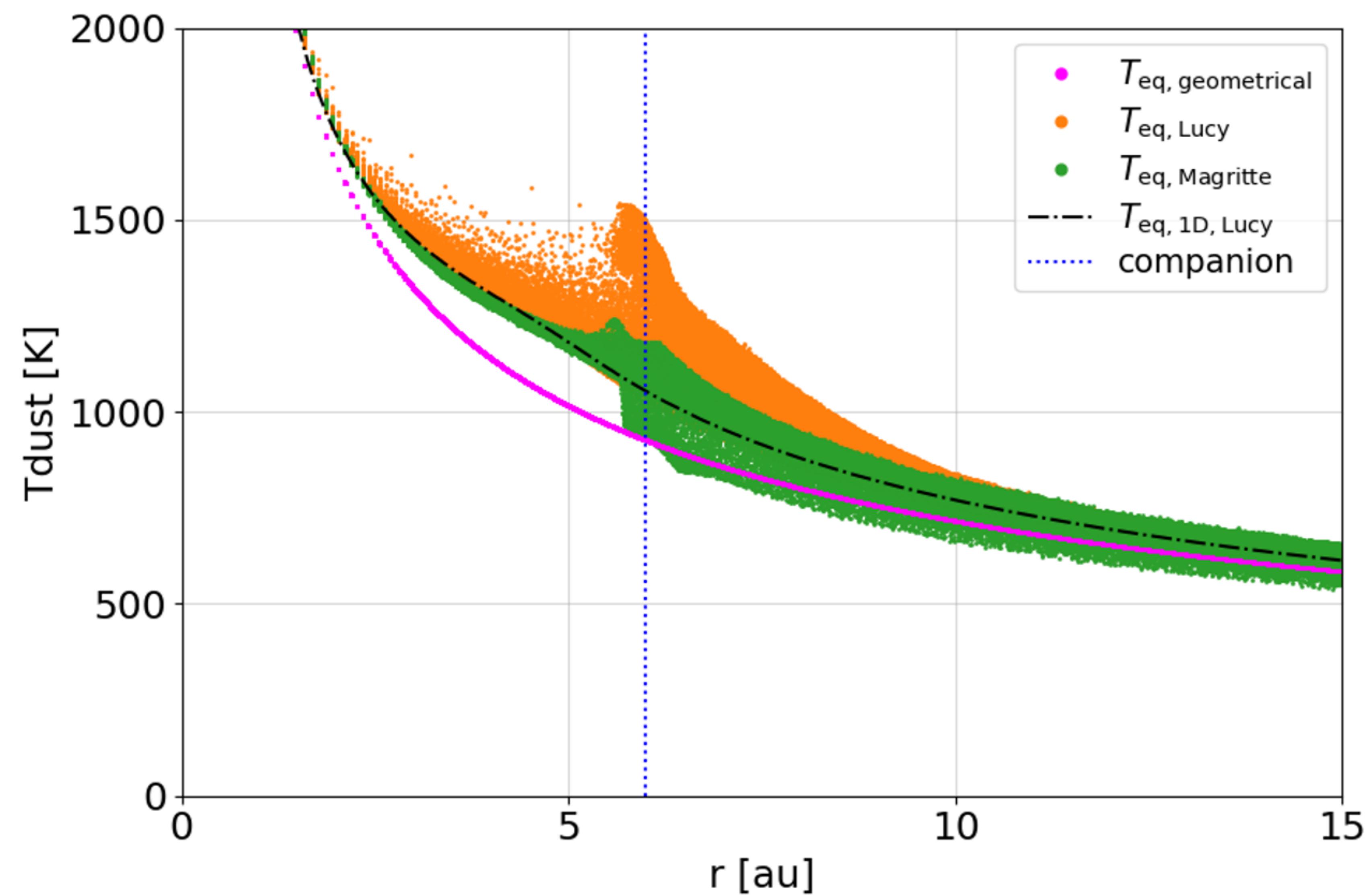
Morphological structures

Parameter	Value	Unit
\dot{M}_{AGB}	10^{-8} or 3×10^{-6}	$\text{M}_\odot \text{ yr}^{-1}$
M_{AGB}	1.02	M_\odot
L_{AGB}	4384	L_\odot
$T_{\text{eff,AGB}}$	2874	K
R_{AGB}	1.24	au
R_{inj}	1.24	au
v_{inj}	33 or 25.2	km s^{-1}
γ	1.2	
μ	2.381	

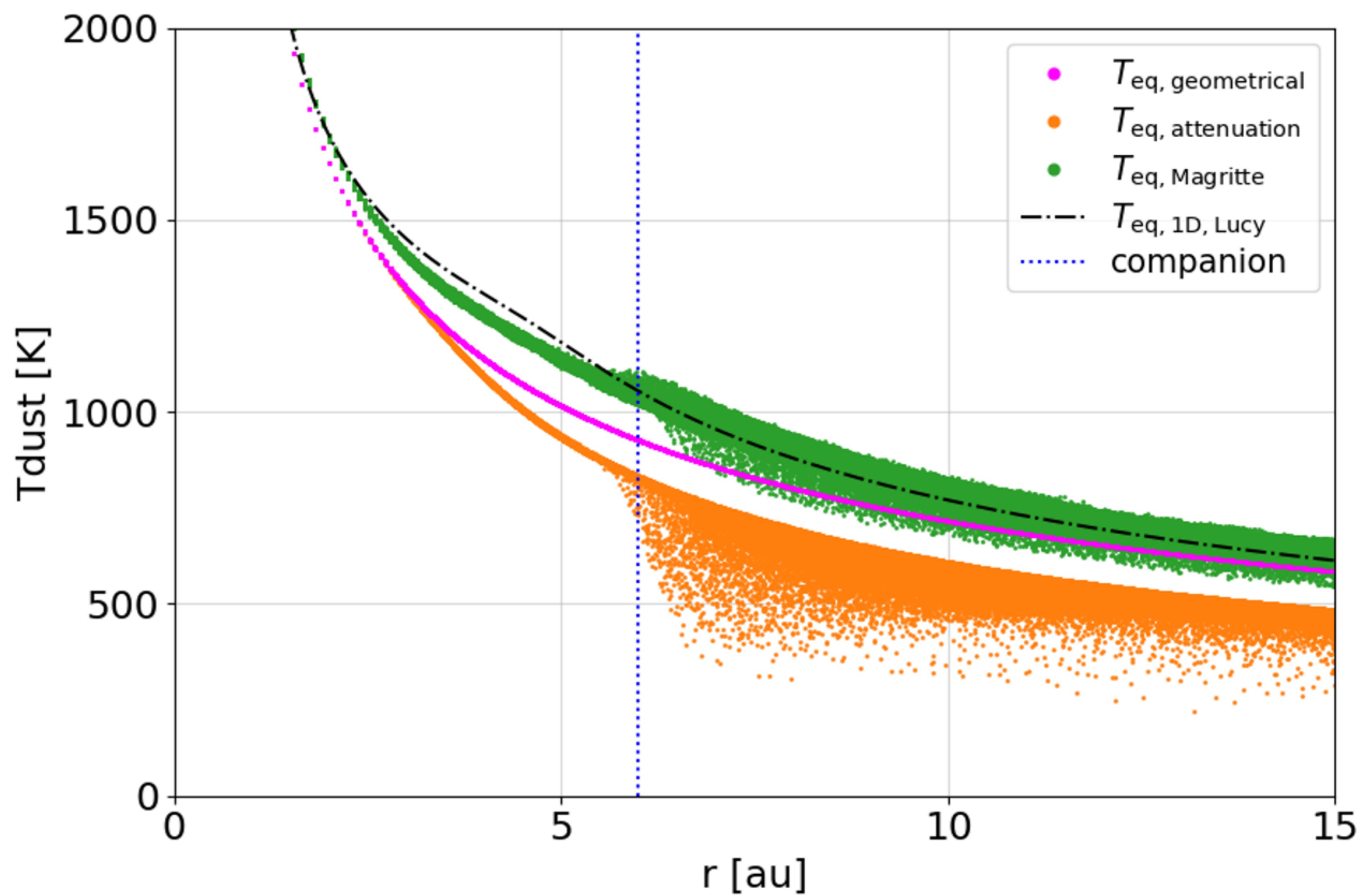


Most adequate approximation

Lucy

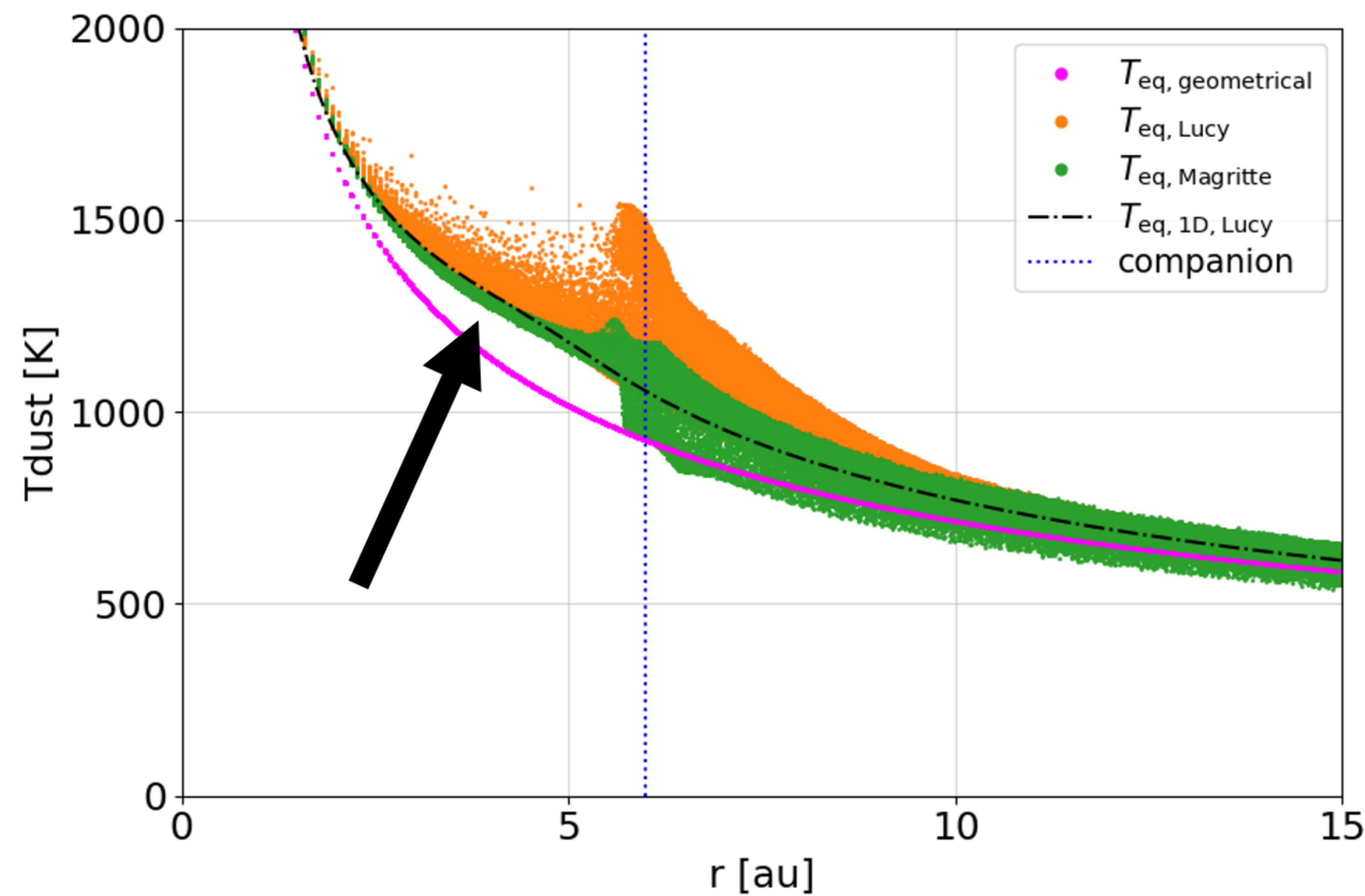


Attenuation

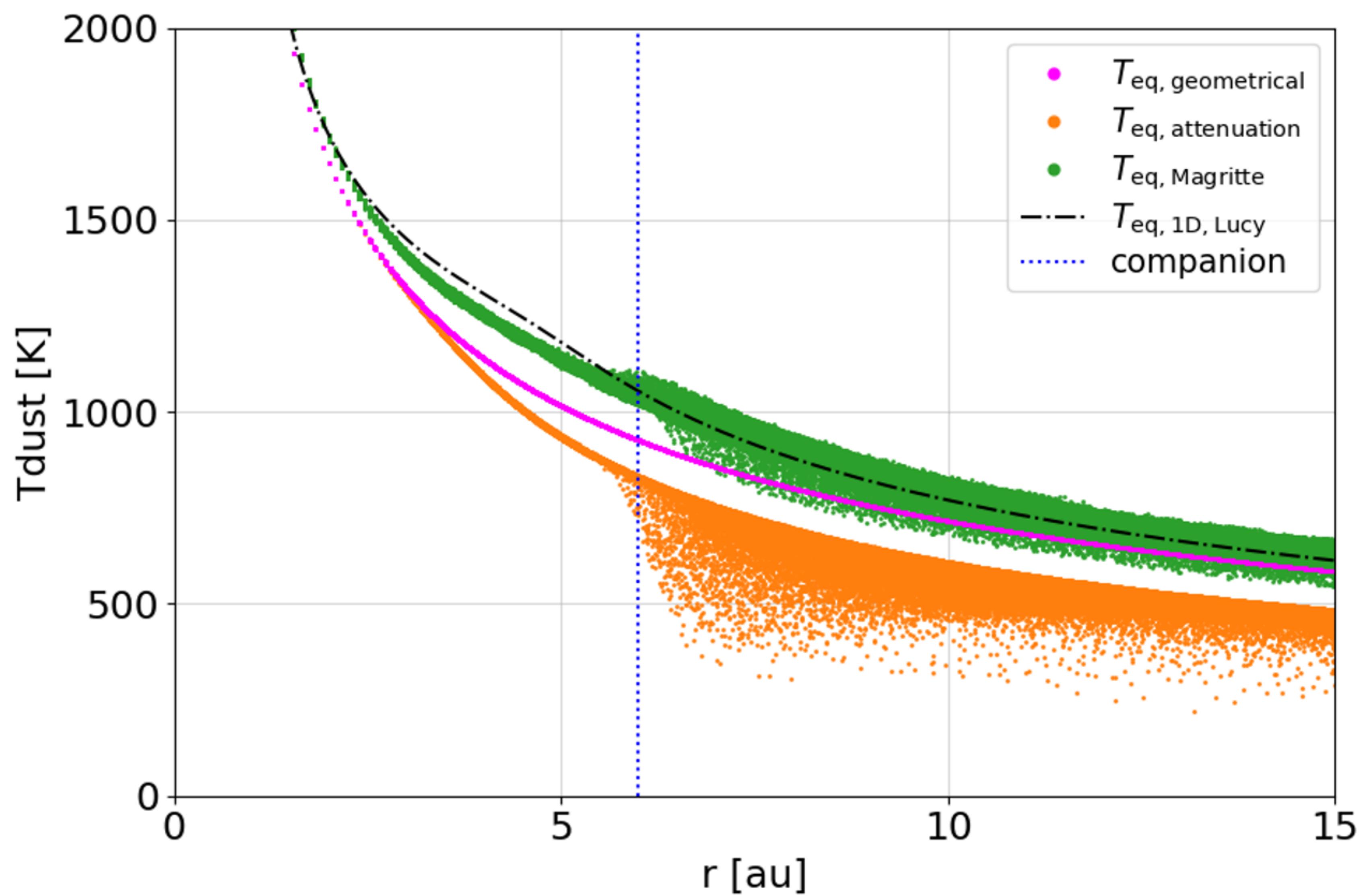


Most adequate approximation

Lucy

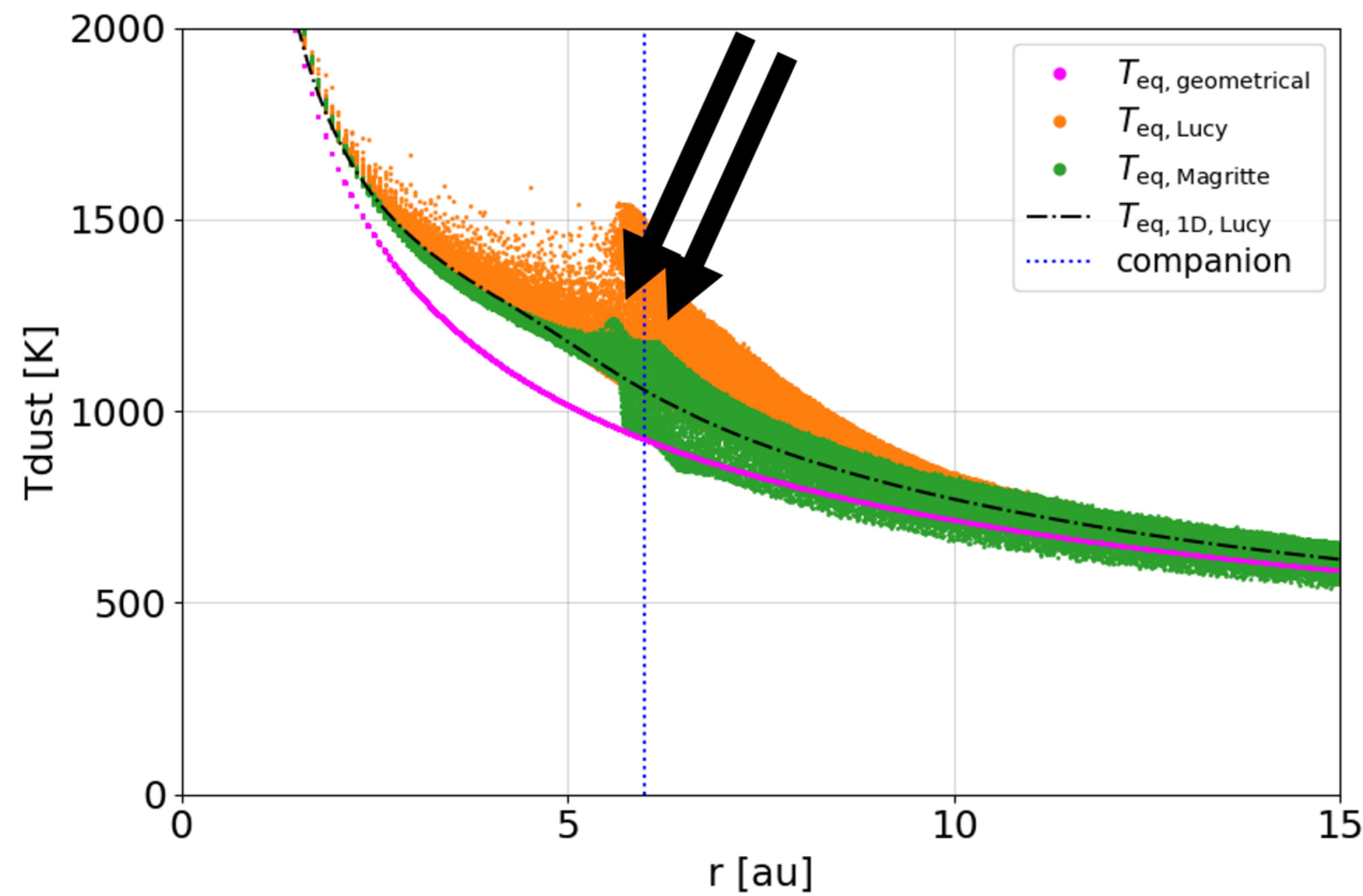


Attenuation

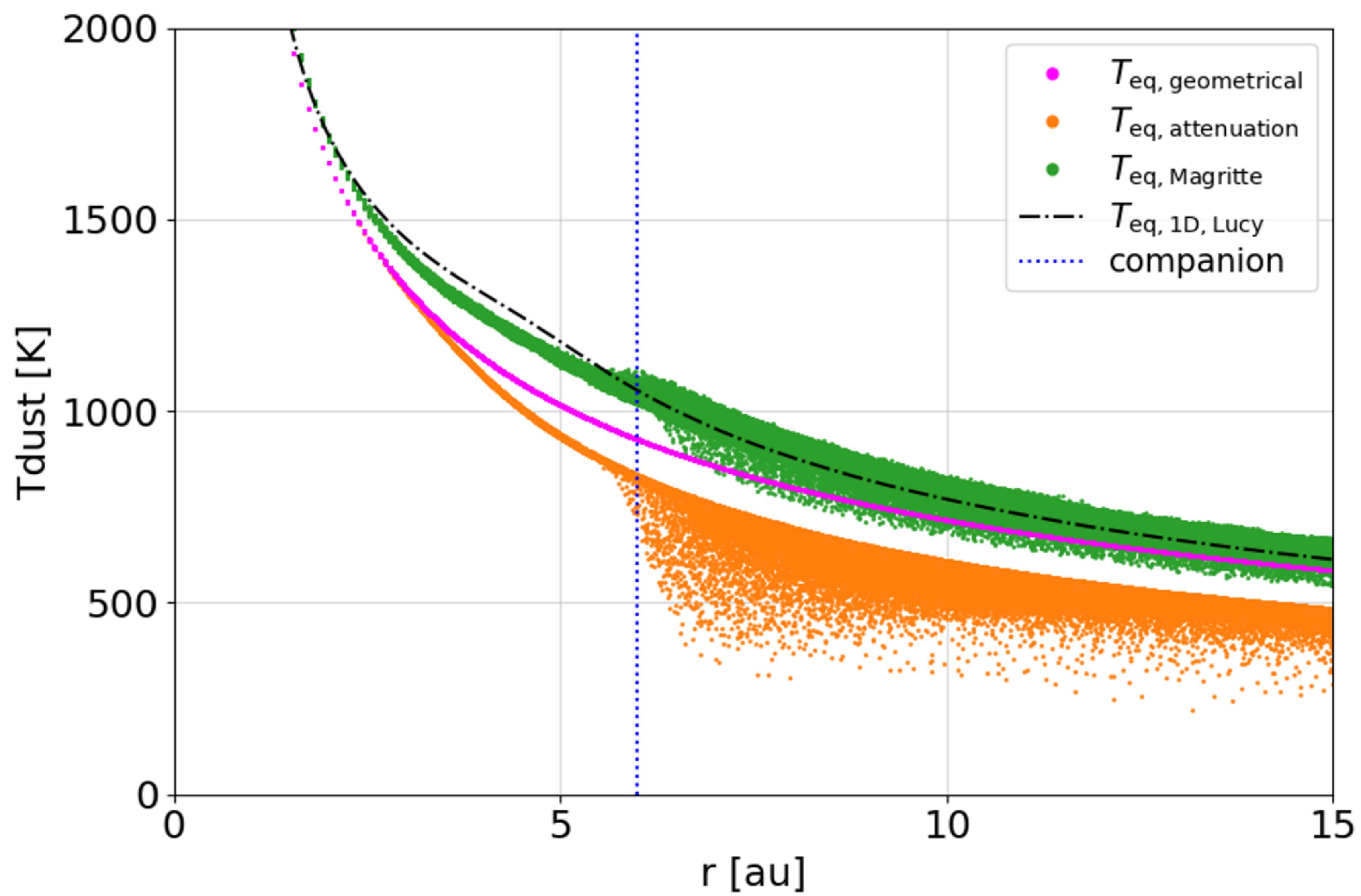


Most adequate approximation

Lucy

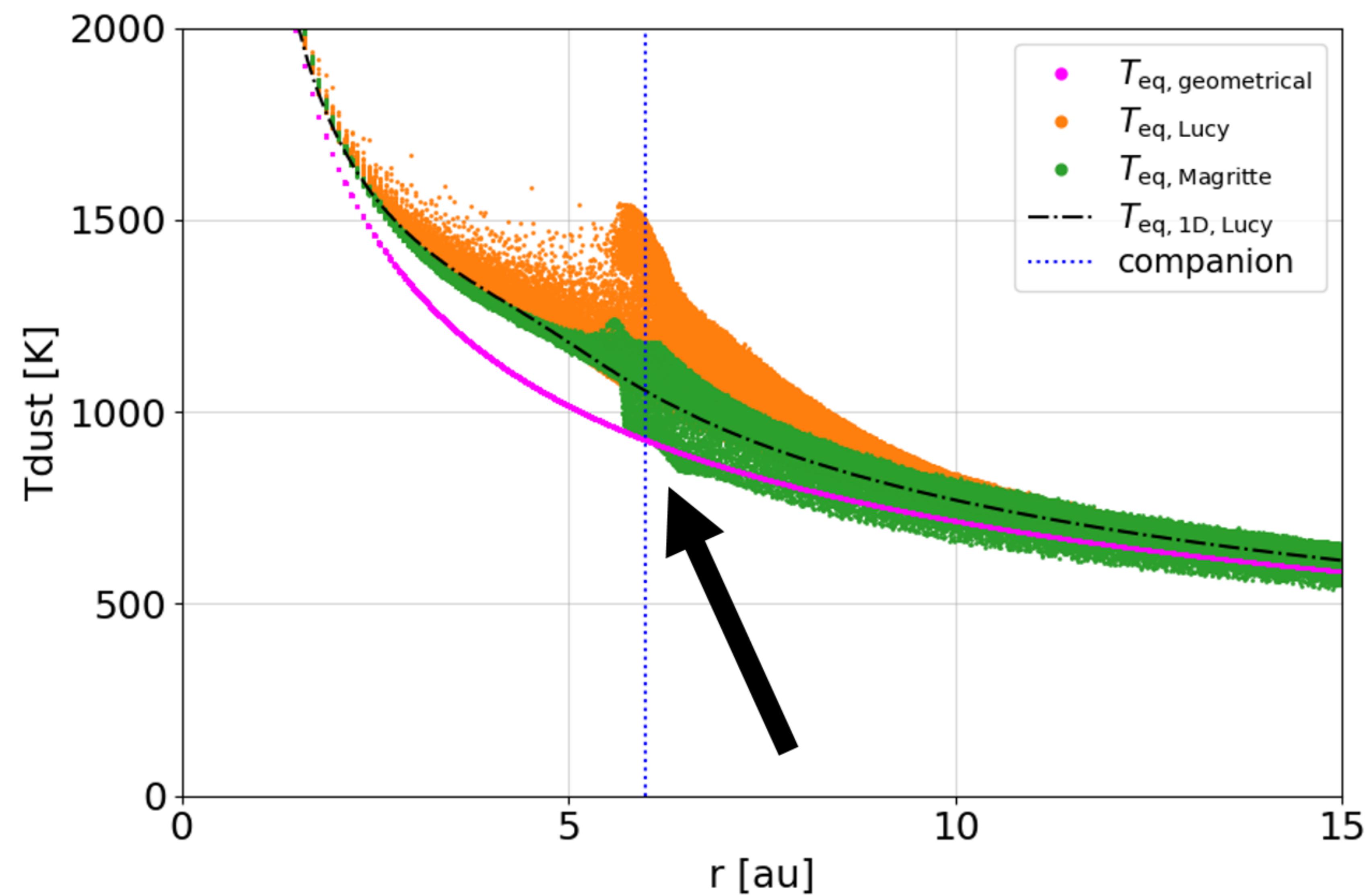


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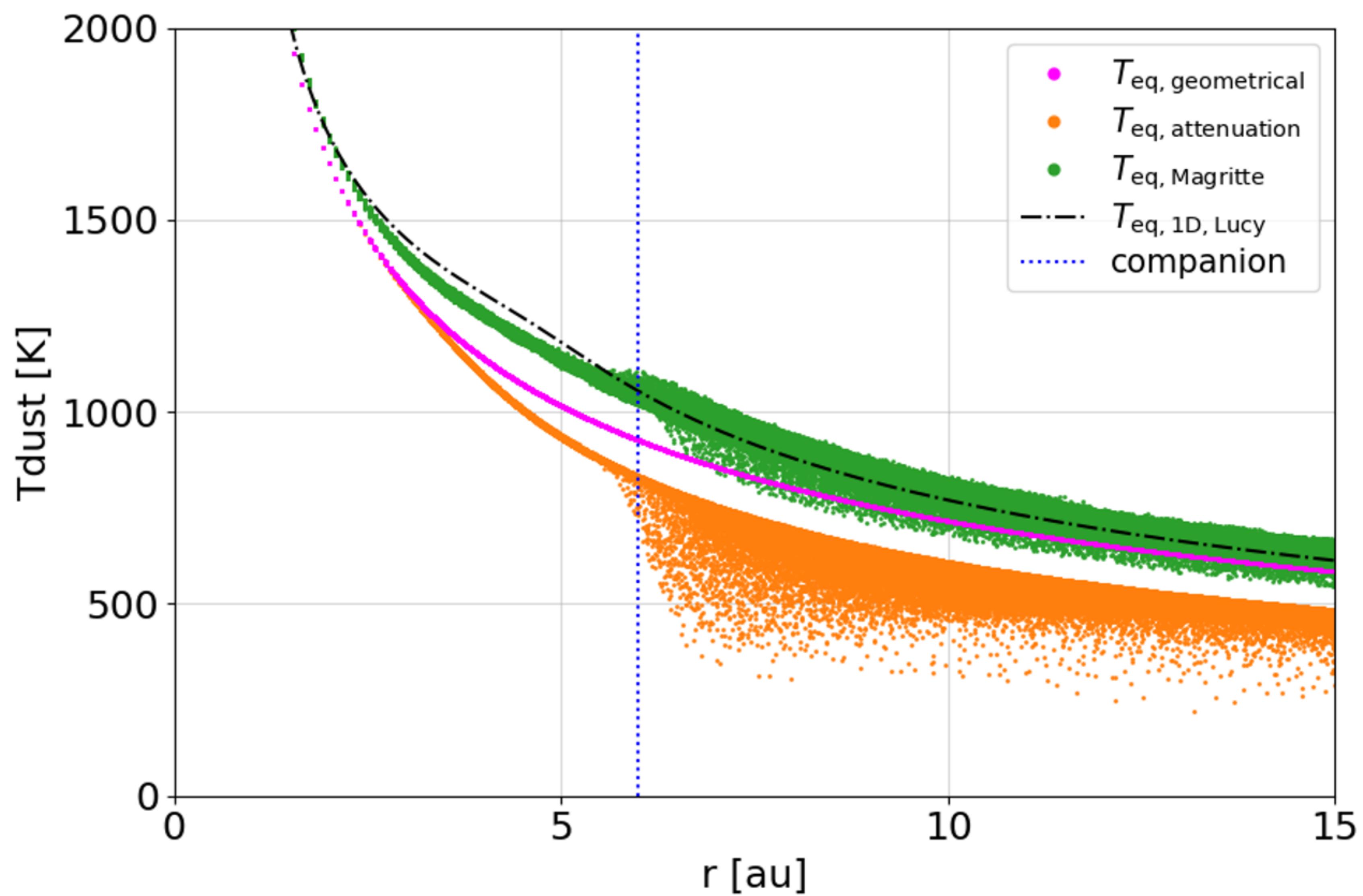


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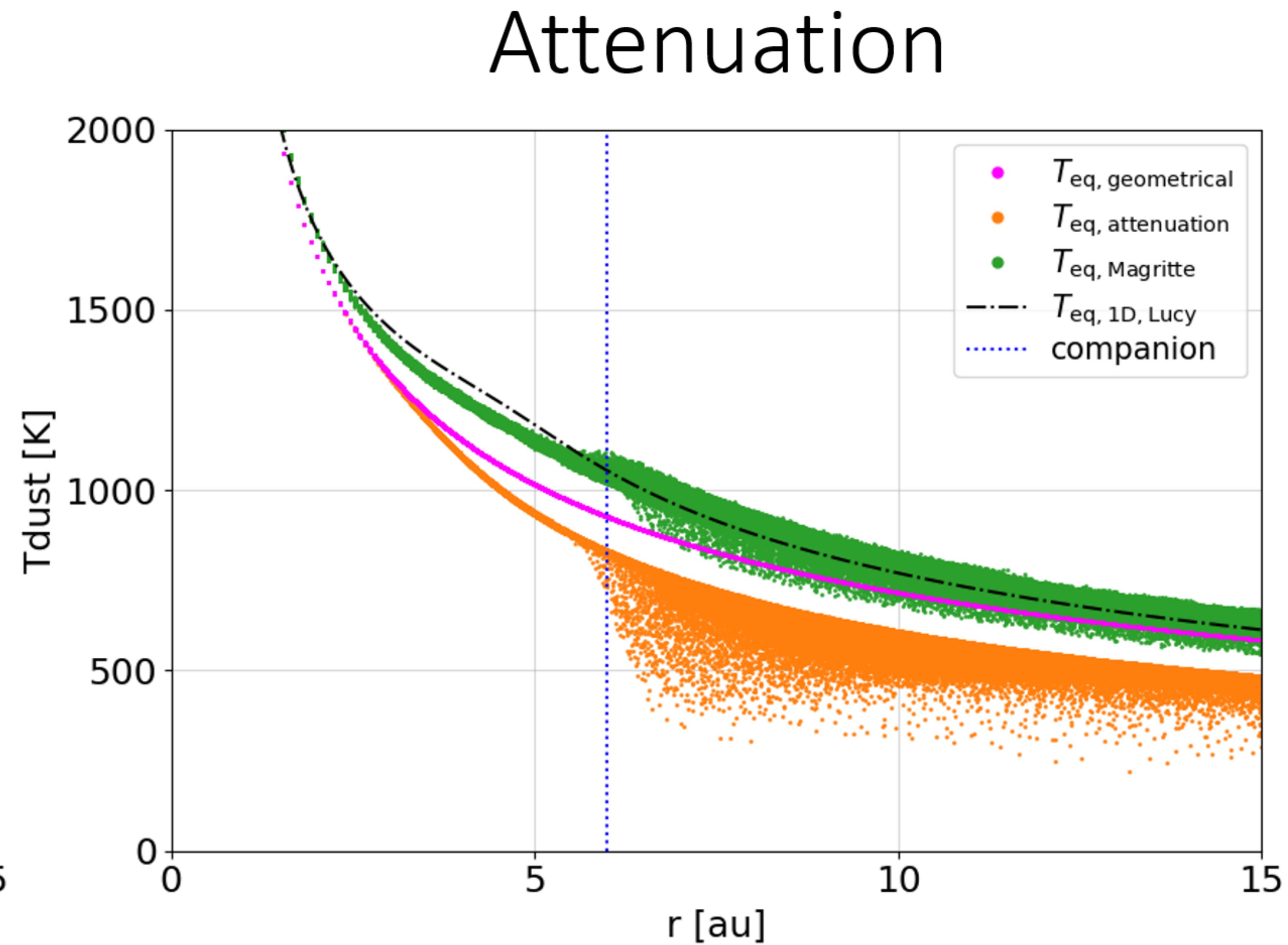
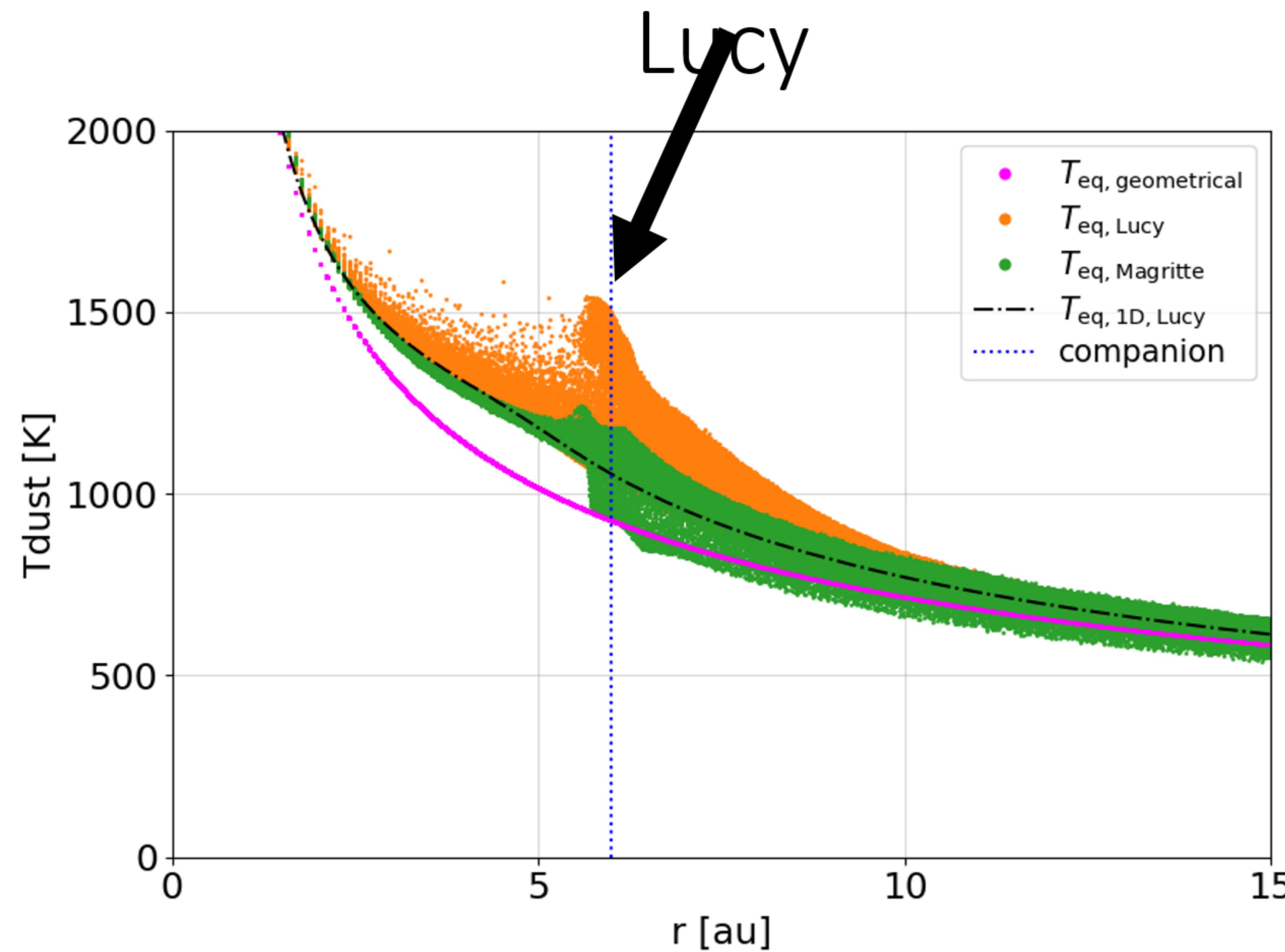
Lucy



Attenuation

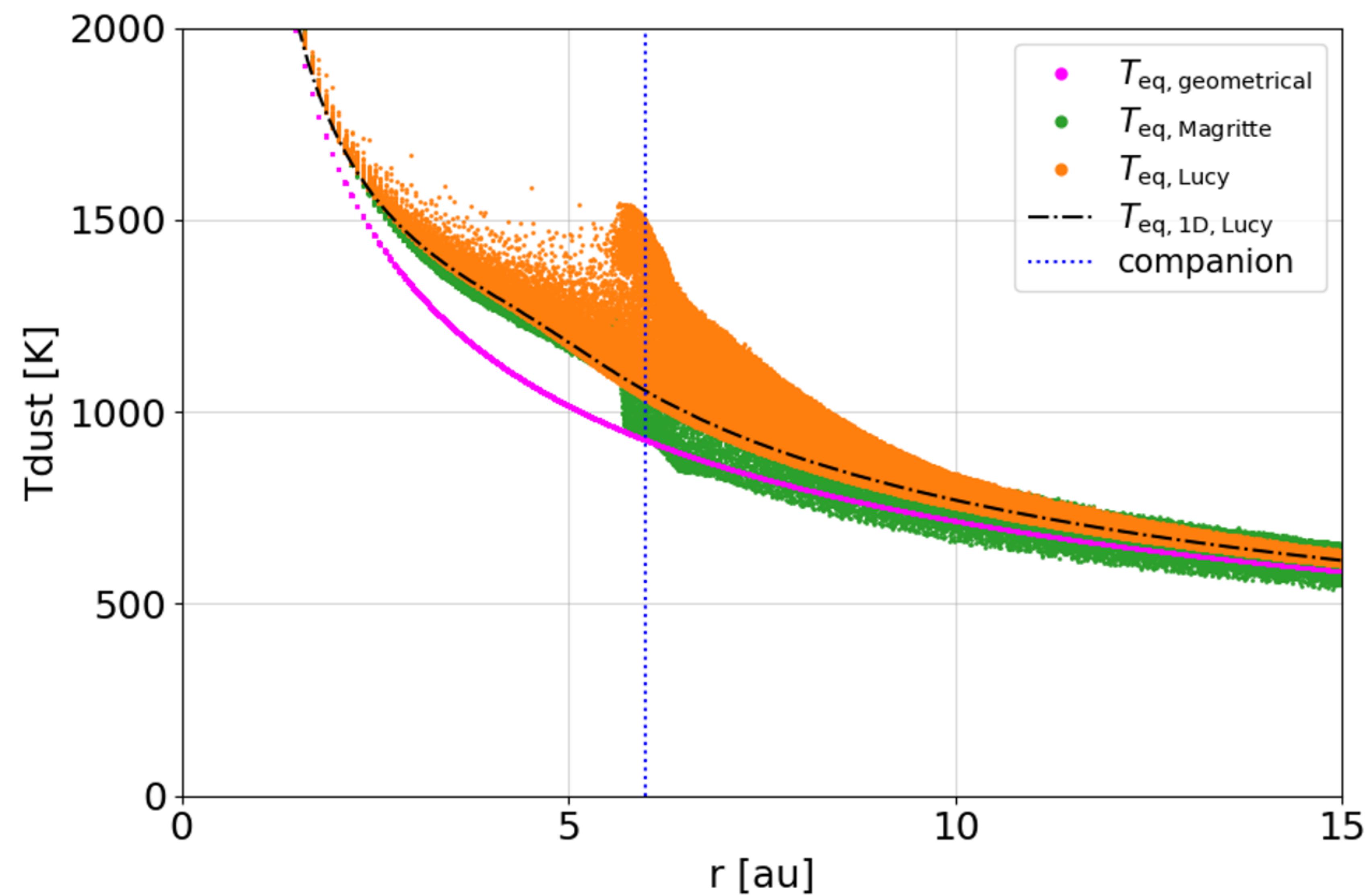


Most adequate approximation

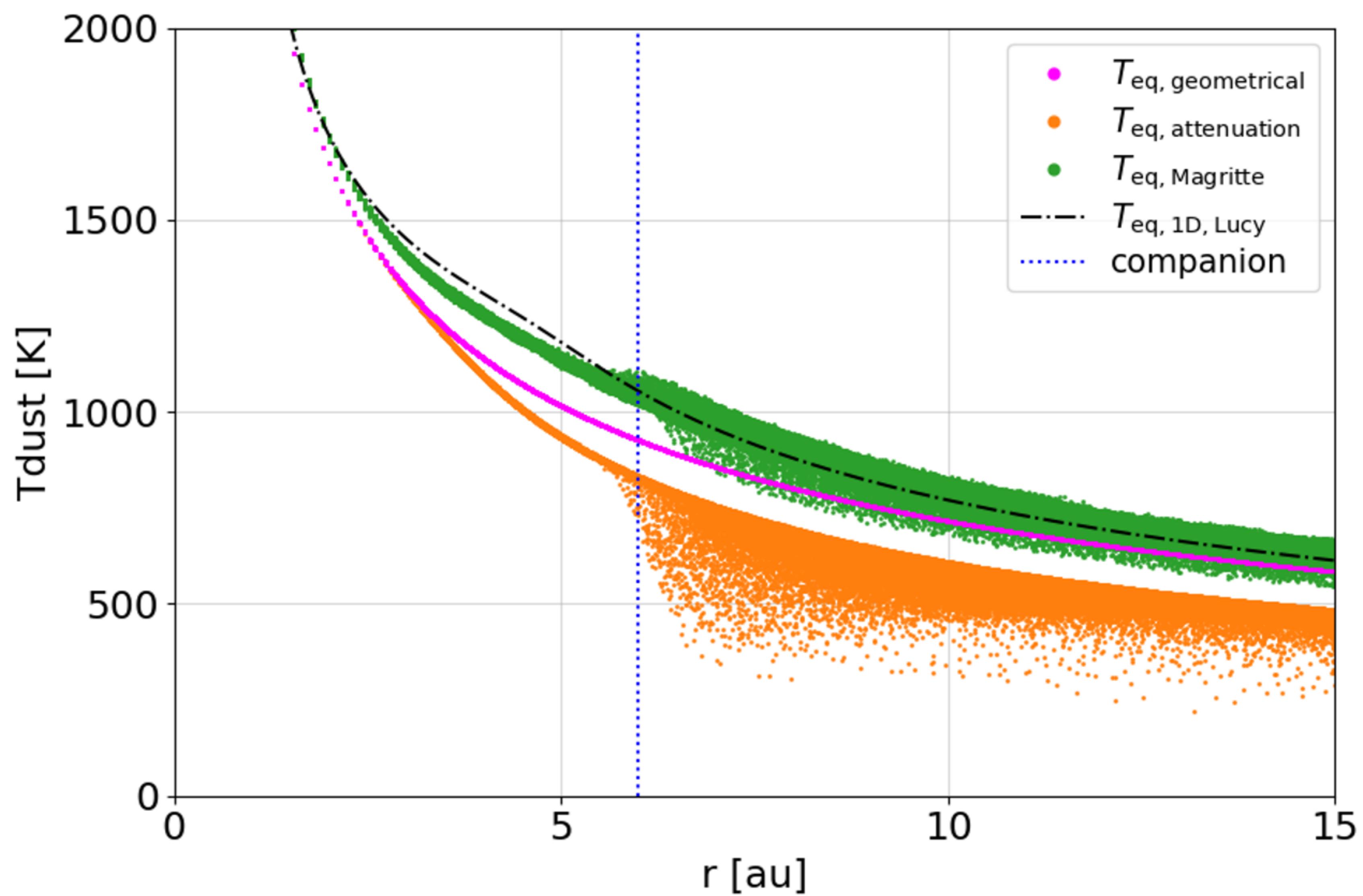


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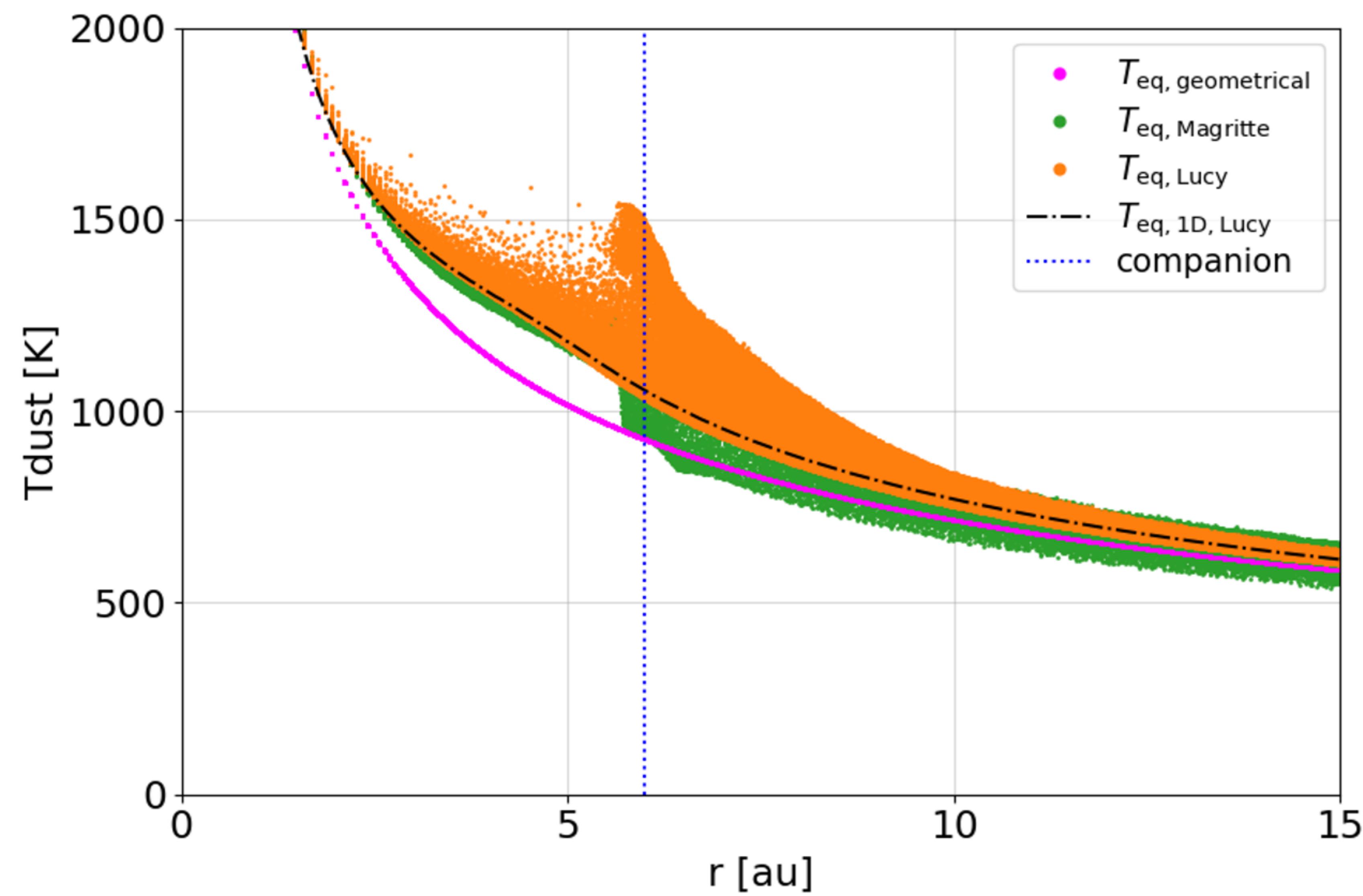


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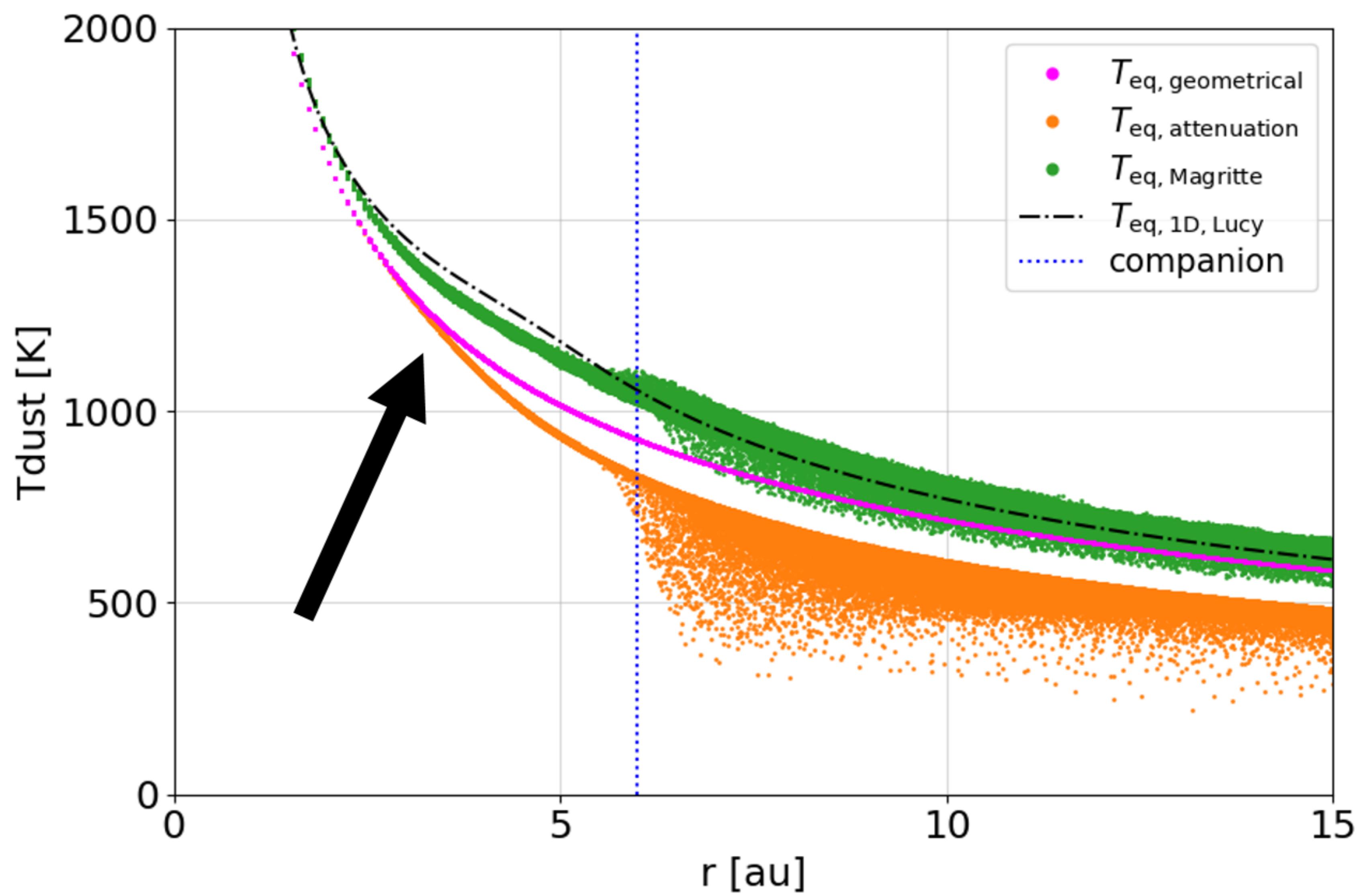


Most adequate approximation

Lucy

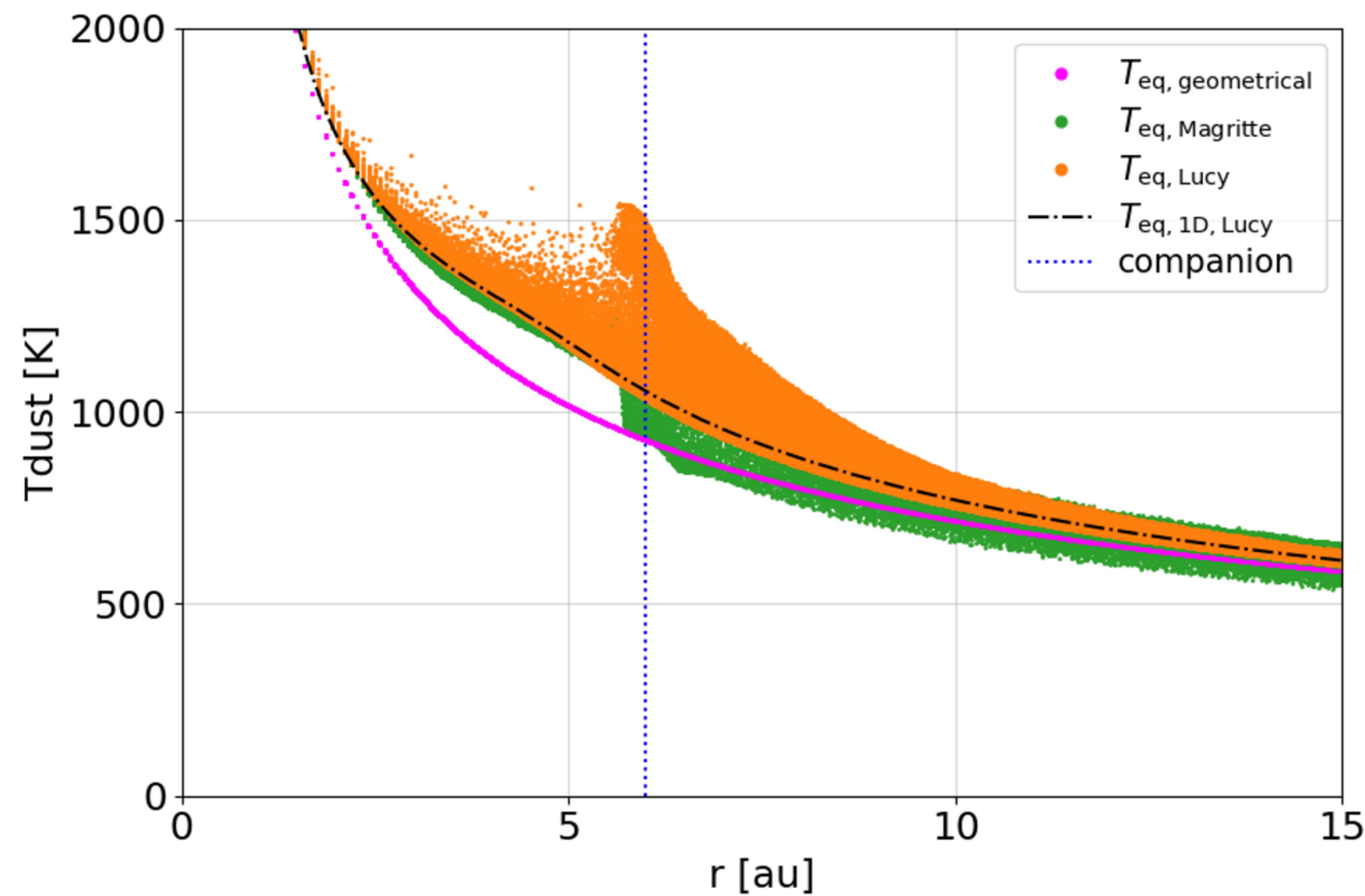


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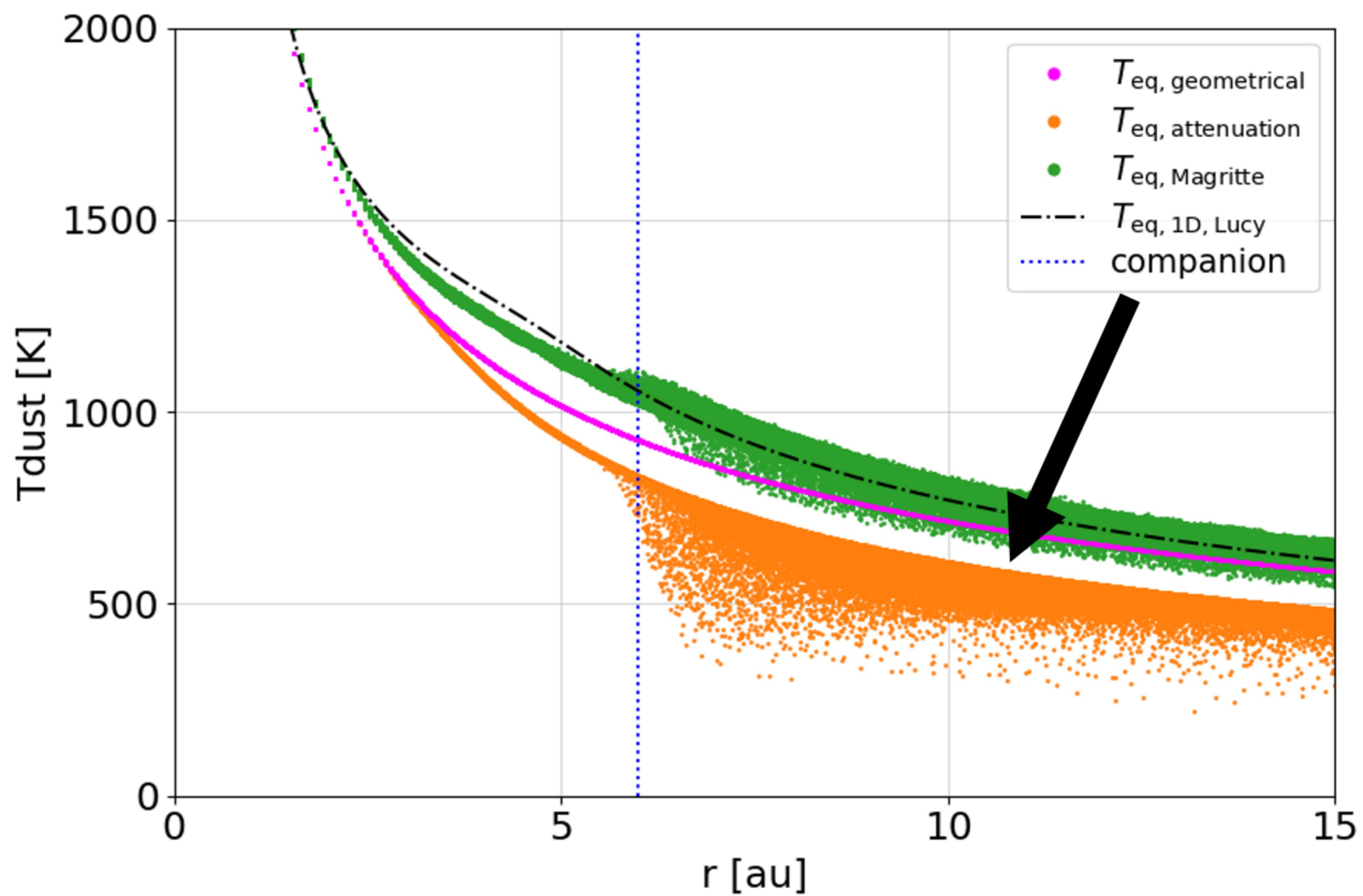


Most adequate approximation

Lucy



Attenuation



8 - 10 March 2023

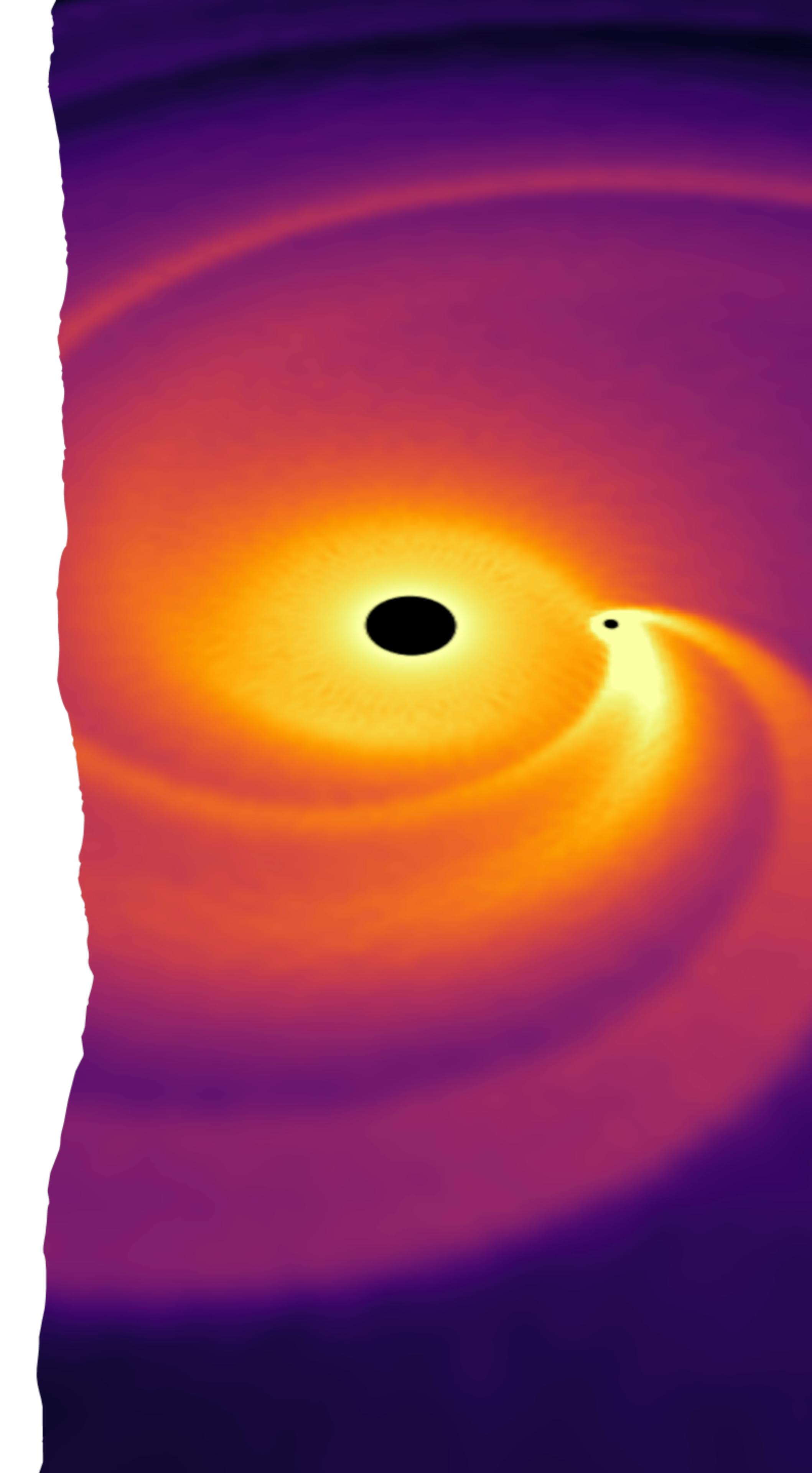
ATOMIUM Meeting winter 2023

MEUDON (FRANCE)
<https://atomium23winter.sciencesconf.org>



Conclusions

- Accounting for dust formation and radiative transfer is crucial in simulating AGB outflows
- The Lucy approximation provides the most accurate results, although it does not account for all effects



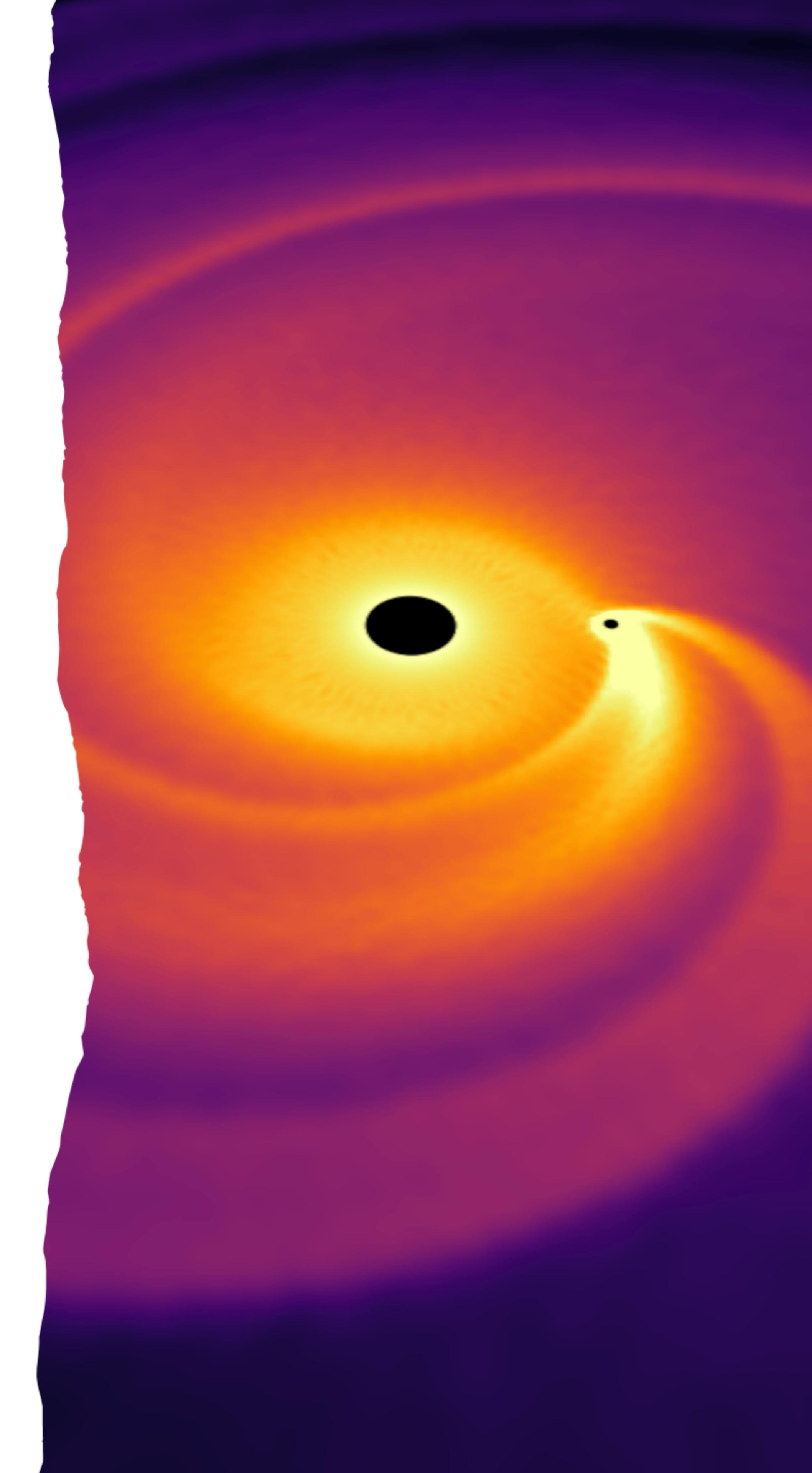
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Outlook

- Cooling
 - H-cooling (Jolien Malfait)
 - More cooling (Lionel Siess)
- Pulsations
 - Follow Aydi & Mohamed (2022)
- Chemistry
 - Chemistry emulator (Silke Maes)
- Comparing models and observations