Difrakčné javy v teleskope

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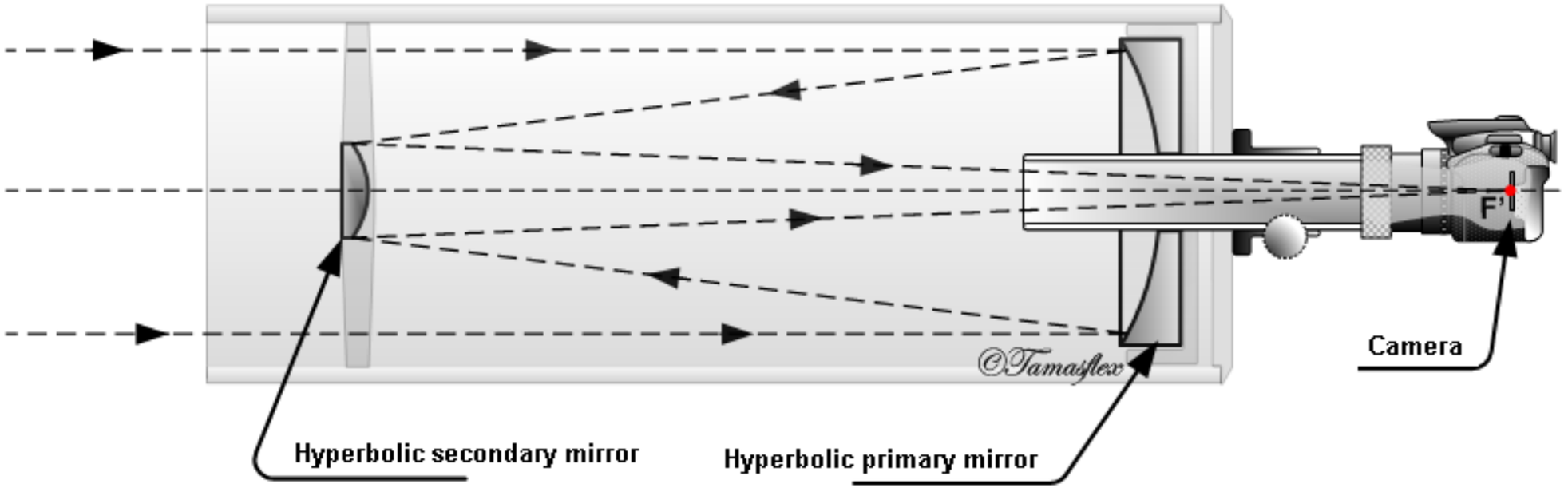
Zadanie úlohy

- Pomocou diskrétnej Fourierovej transformácie nájdite zdanlivý obraz bodového zdroja pozorovaný ďalekohľadom

$$I = \left| \iint T(x,y)\, \mathrm{e}^{-i(k_x x + k_y y)}\, \mathrm{d}x\, \mathrm{d}y \right|^2$$

- Porovnajte prípad jednoduchého kruhového otvoru so známym analytickým riešením
- Pridajte kruhovú prepážku predstavujúcu sekundárne zrkadlo a skúmajte vplyv jej polomeru
- Nakoniec zakomponujte aj štvorramenný a trojramenný držiak sekundárneho zrkadla, prípadne trojramenný držiak s polkruhovými ramenami

Teleskop



Ritchey - Chrétien (RCT)

Diskrétna Fourierova transformácia

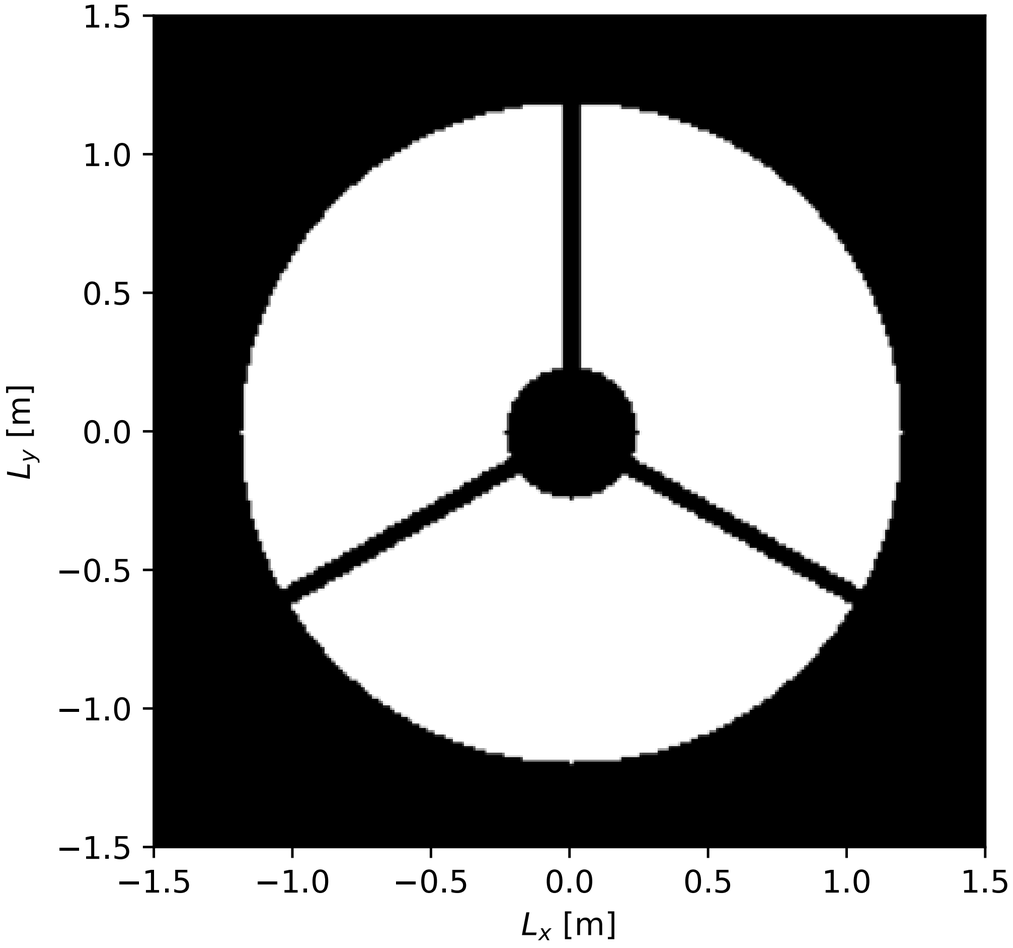
- 1D definícia: $$c_k = \sum_{j=0}^{N-1} f_j \cdot e^{-i\frac{2\pi}{N}jk}$$

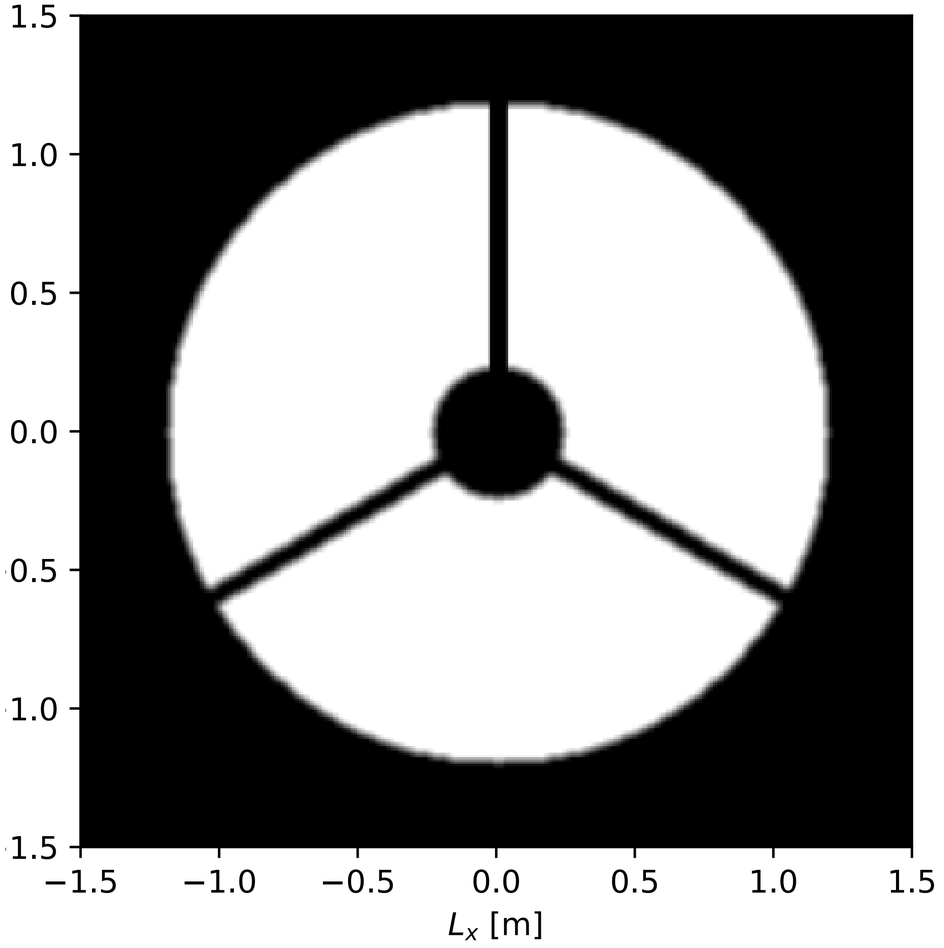
$$I = \left| \iint T(x,y)\, \mathrm{e}^{-i(k_x x + k_y y)}\, \mathrm{d}x\, \mathrm{d}y \right|^2$$

$$k_x = \frac{2\pi}{L} k_1 \quad \rightarrow \quad \varphi_x = \frac{\lambda}{L} k_1$$

$$k_x \approx \frac{2\pi}{\lambda} \varphi_x$$

Apertúra


1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
L_y [m]
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
L_x [m]


1.5
1.0
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0.0
0.5
1.0
1.5
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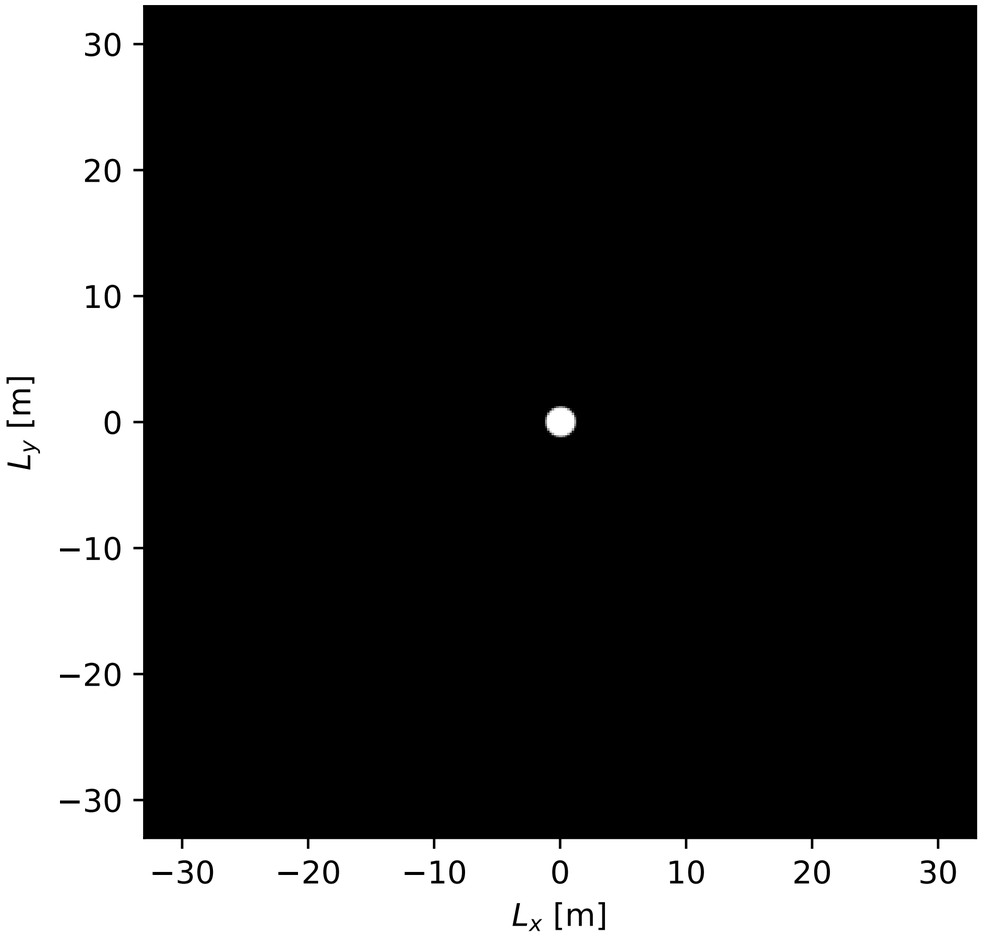
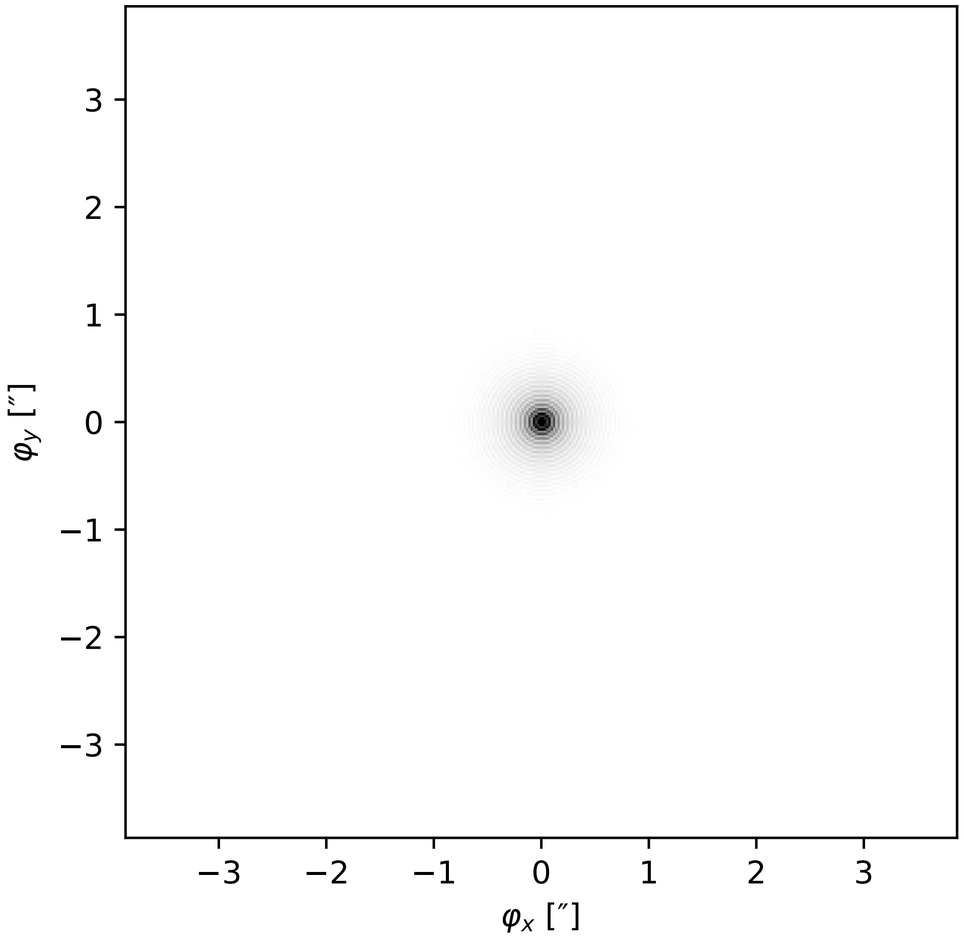
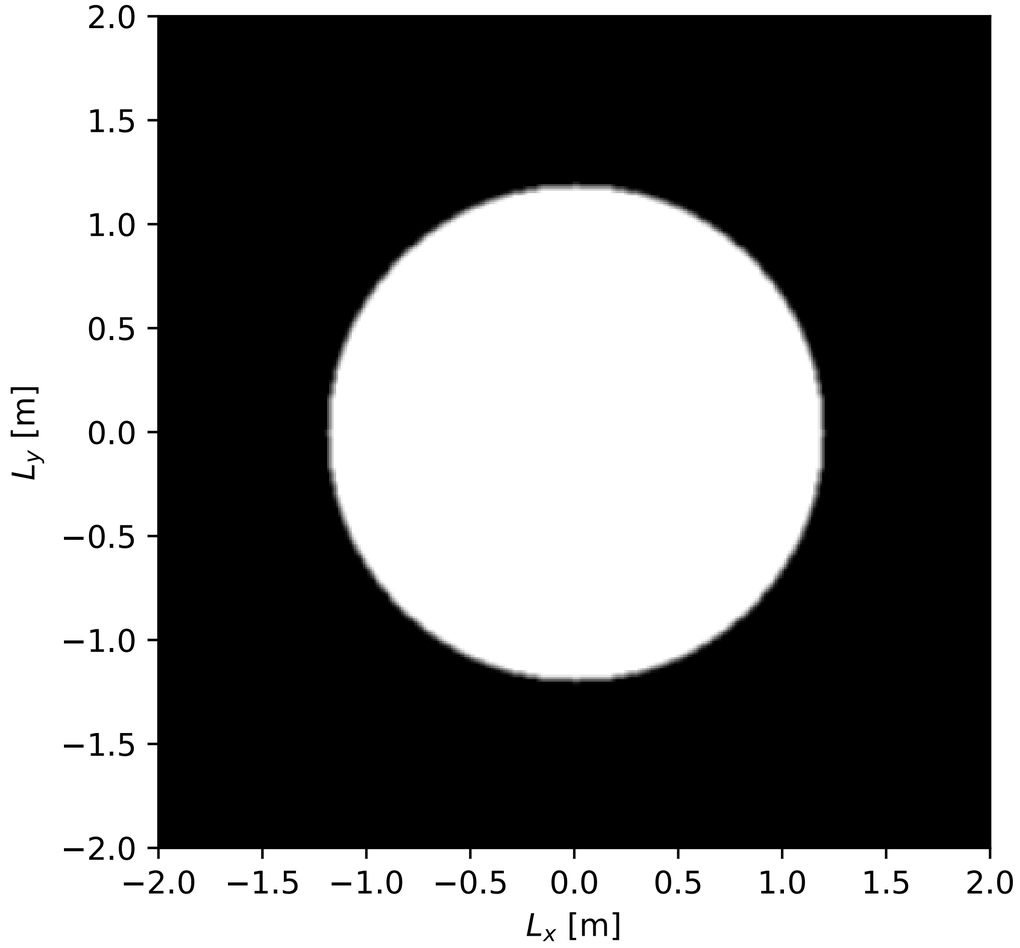
0.0
0.5
1.0
1.5
L_x [m]

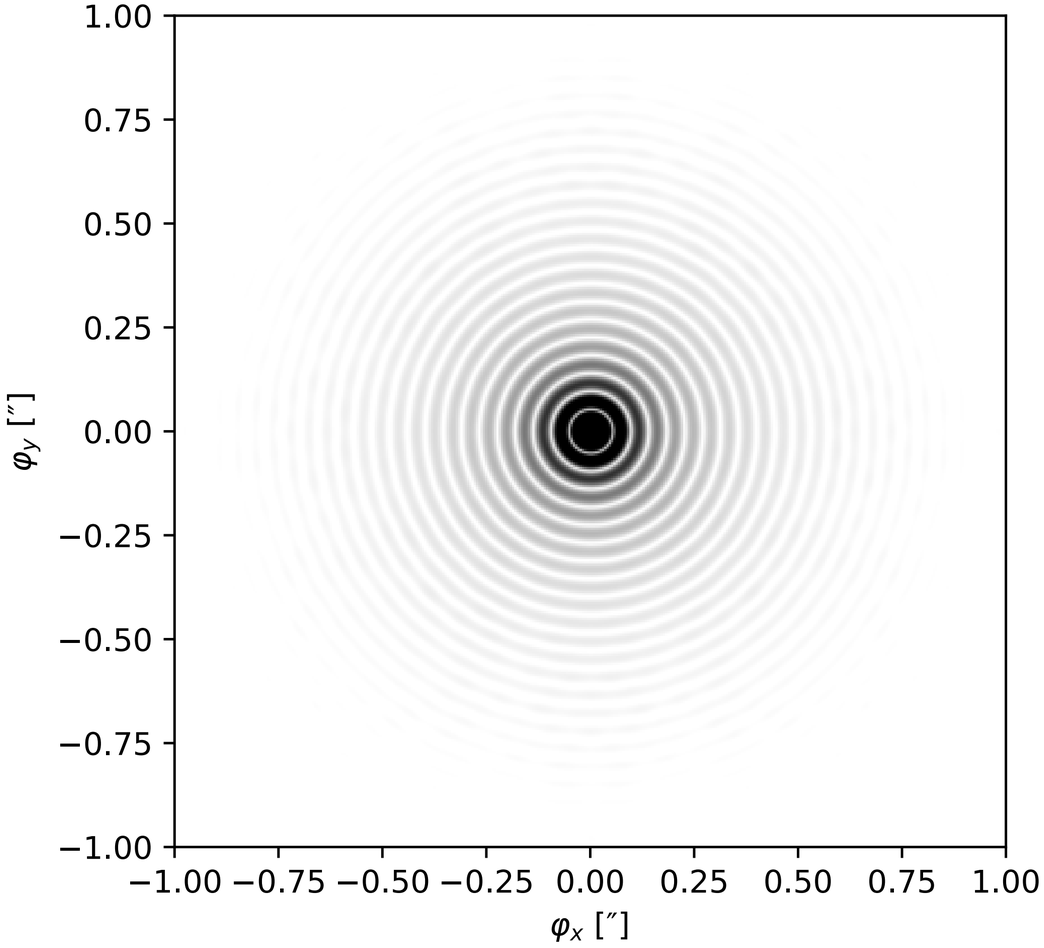
Jednoduchý kruhový otvor





Jednoduchý kruhový otvor





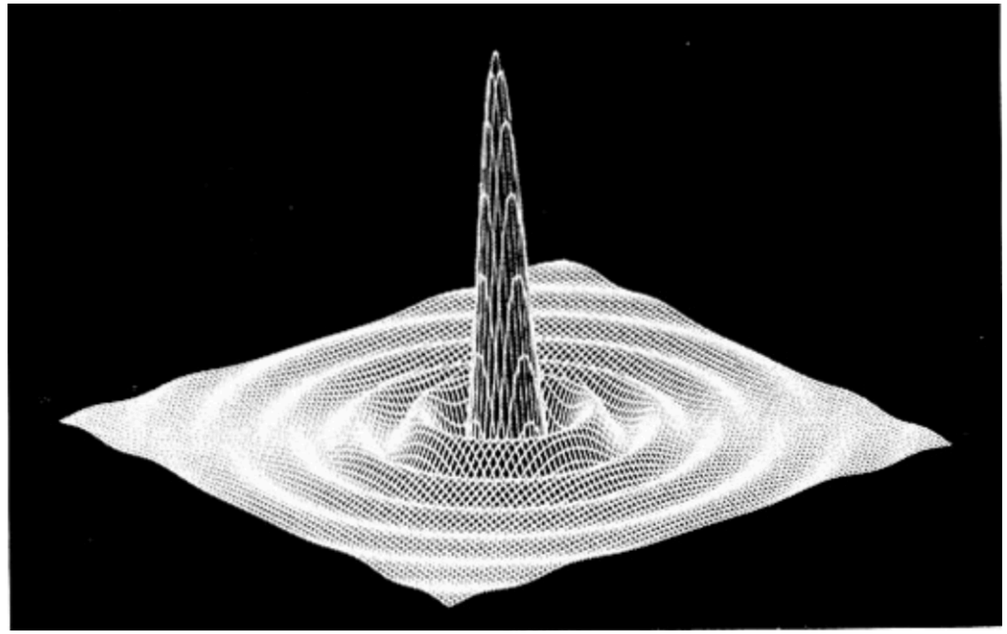
Fraunhoferova difrakcia na kruhovom otvore

Airyho disk

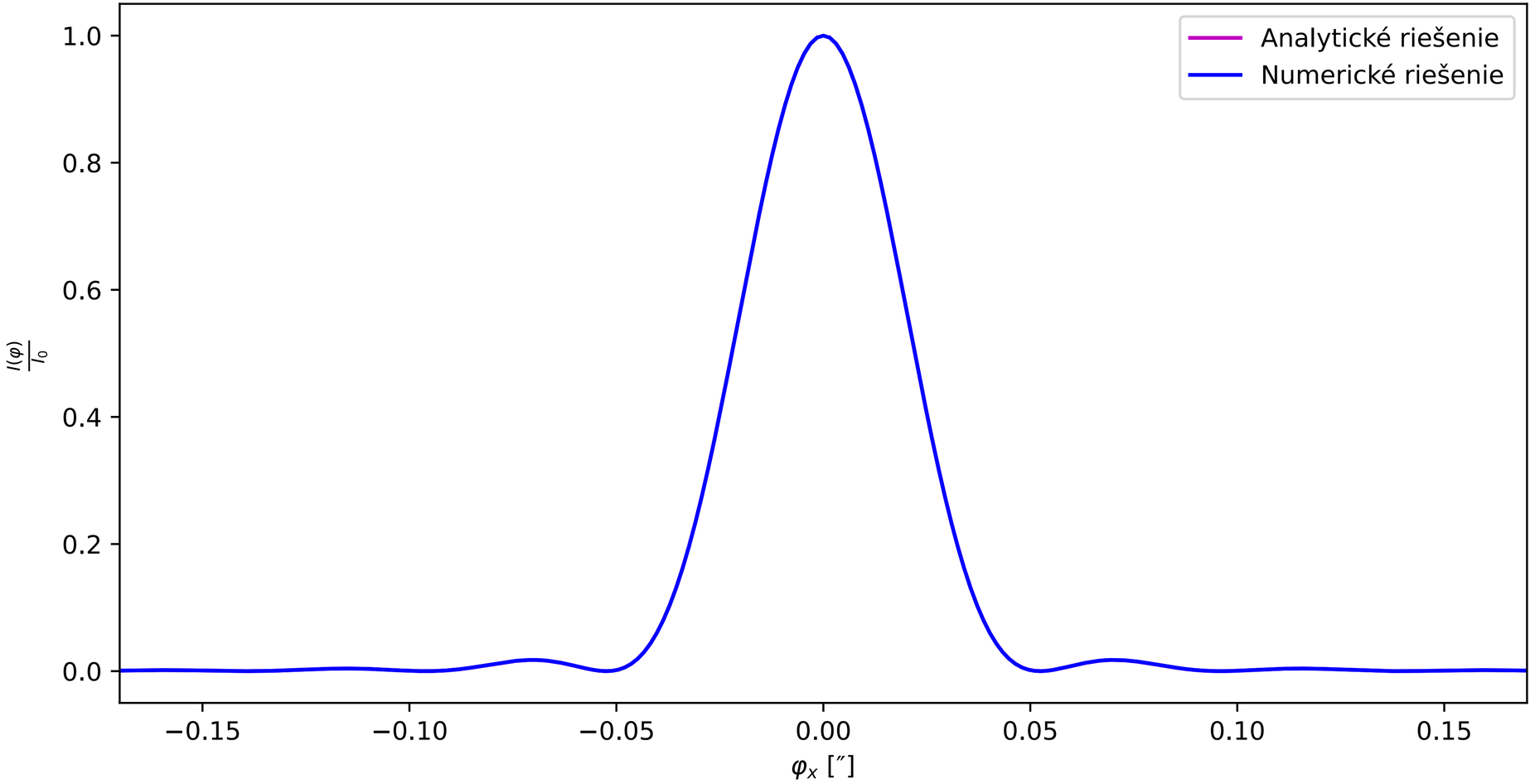
$$I(\varphi) = I_0 \left[\frac{2J_1(x)}{x} \right]^2$$

kde $x = ka \sin\varphi = \frac{2\pi a}{\lambda} \sin\varphi \approx \frac{\pi D}{\lambda}\varphi$

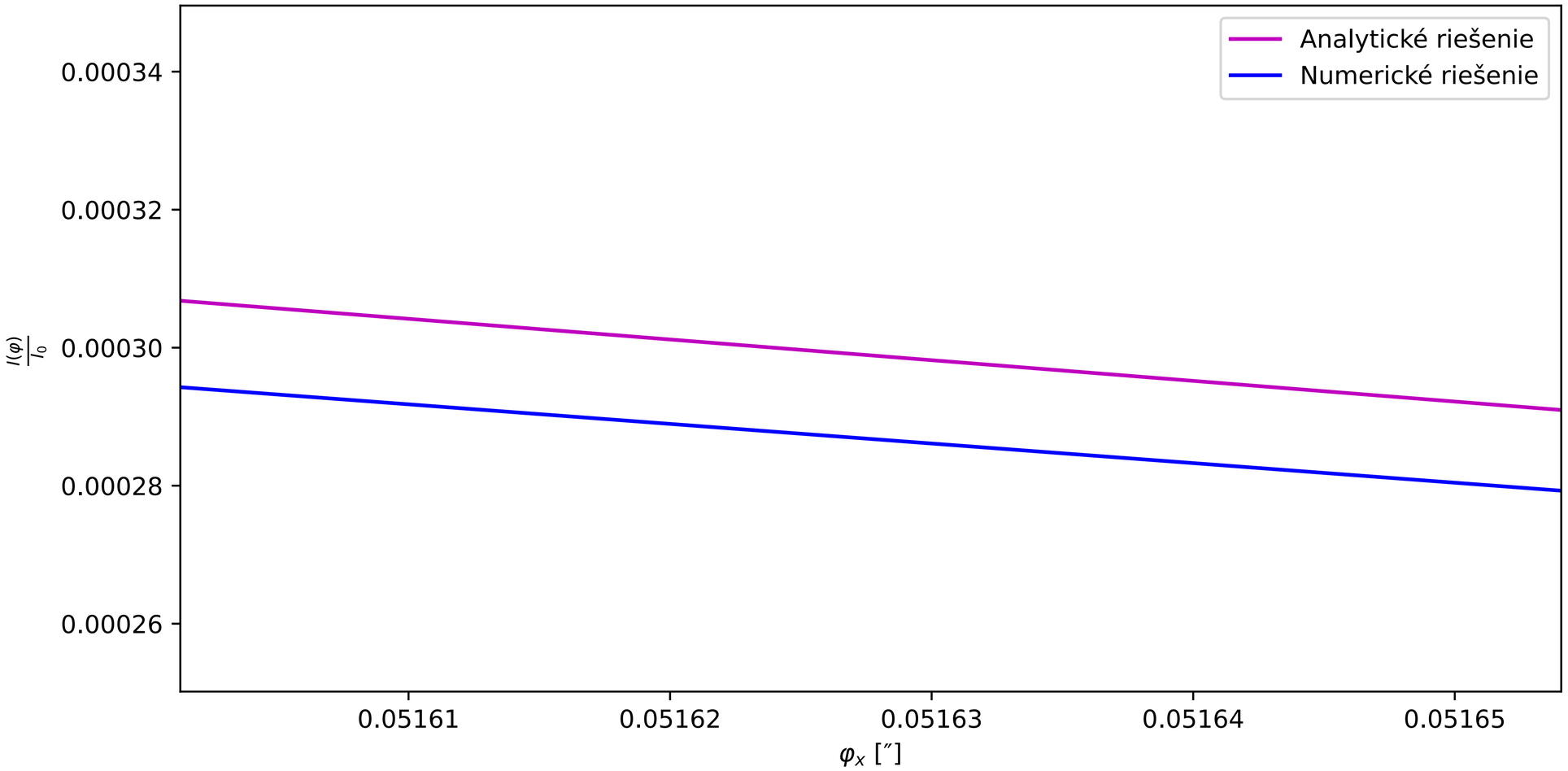
$$\rho_{spot} = 1.22 \frac{\lambda}{D}$$



Jednoduchý kruhový otvor — porovnanie s analytickým riešením

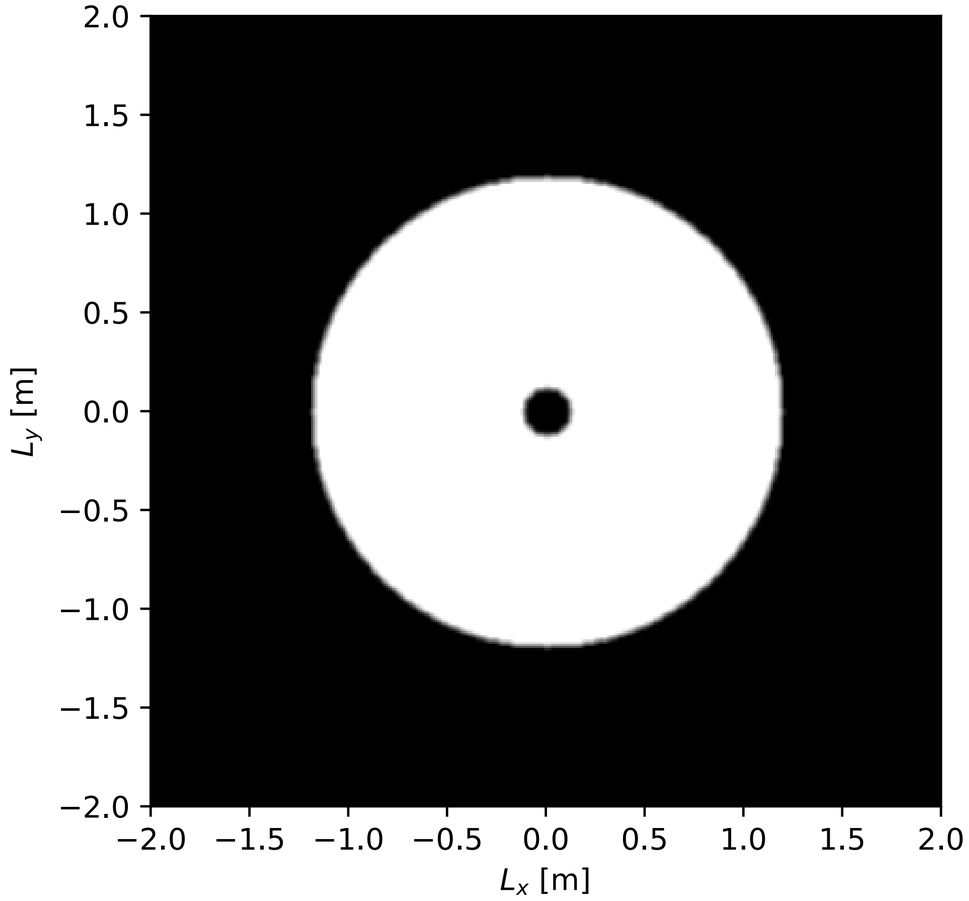


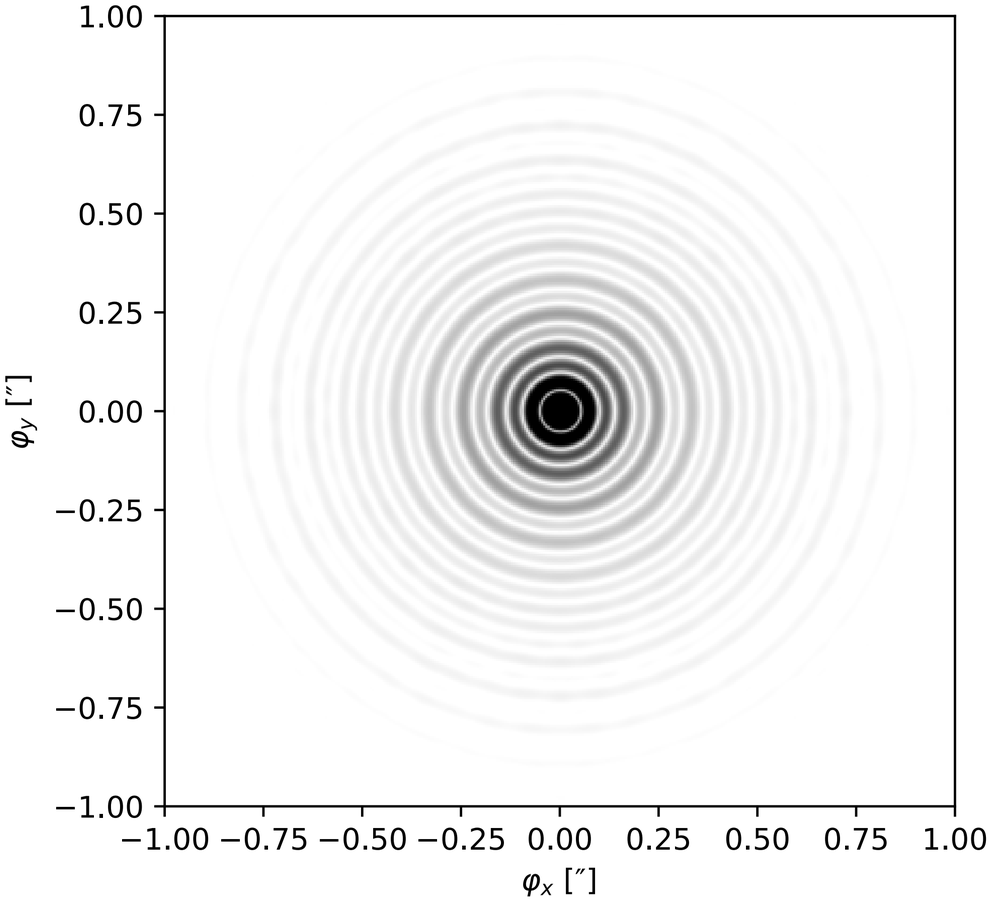
Jednoduchý kruhový otvor — porovnanie s analytickým riešením



Sekundárne zrkadlo — kruhová prepážka

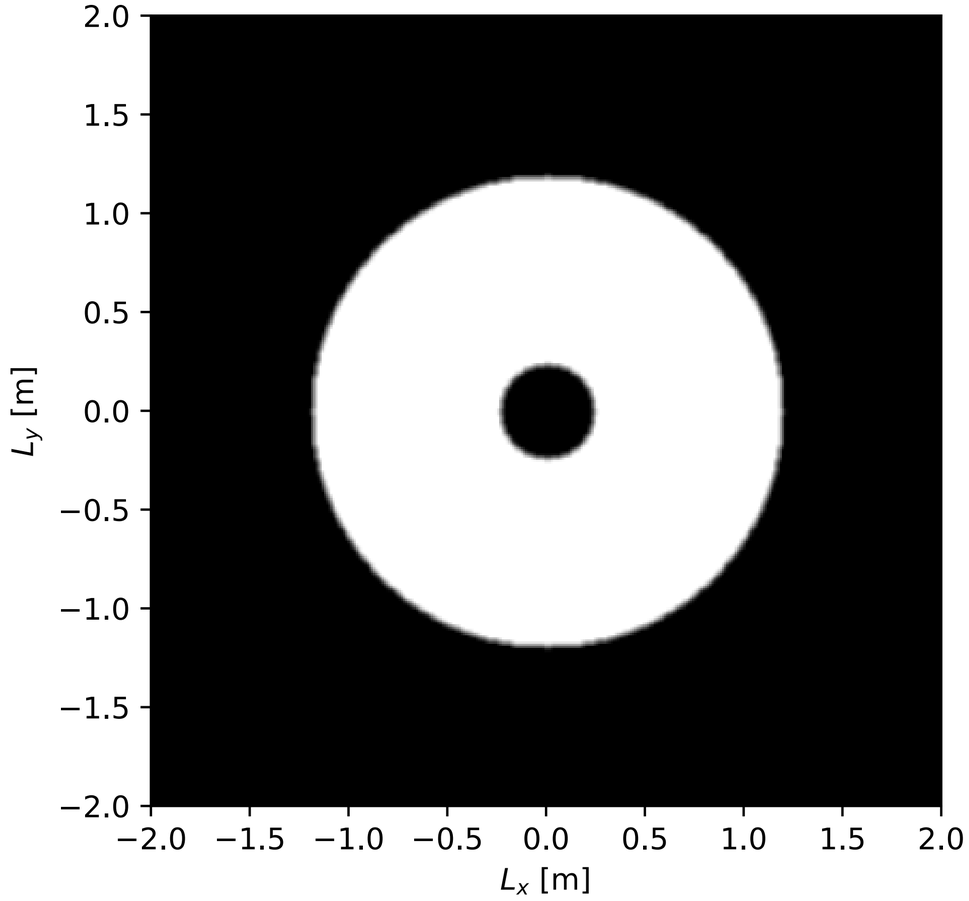
$R = 0.1 \cdot D$

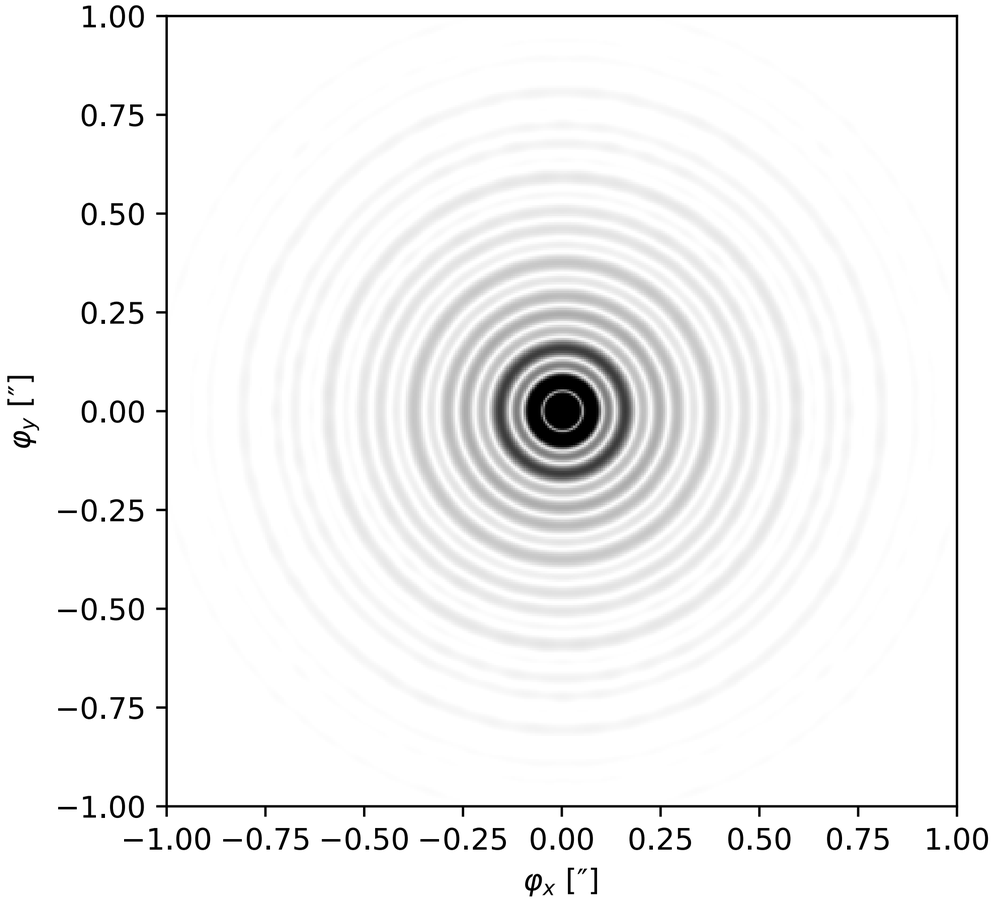




Sekundárne zrkadlo — kruhová prepážka

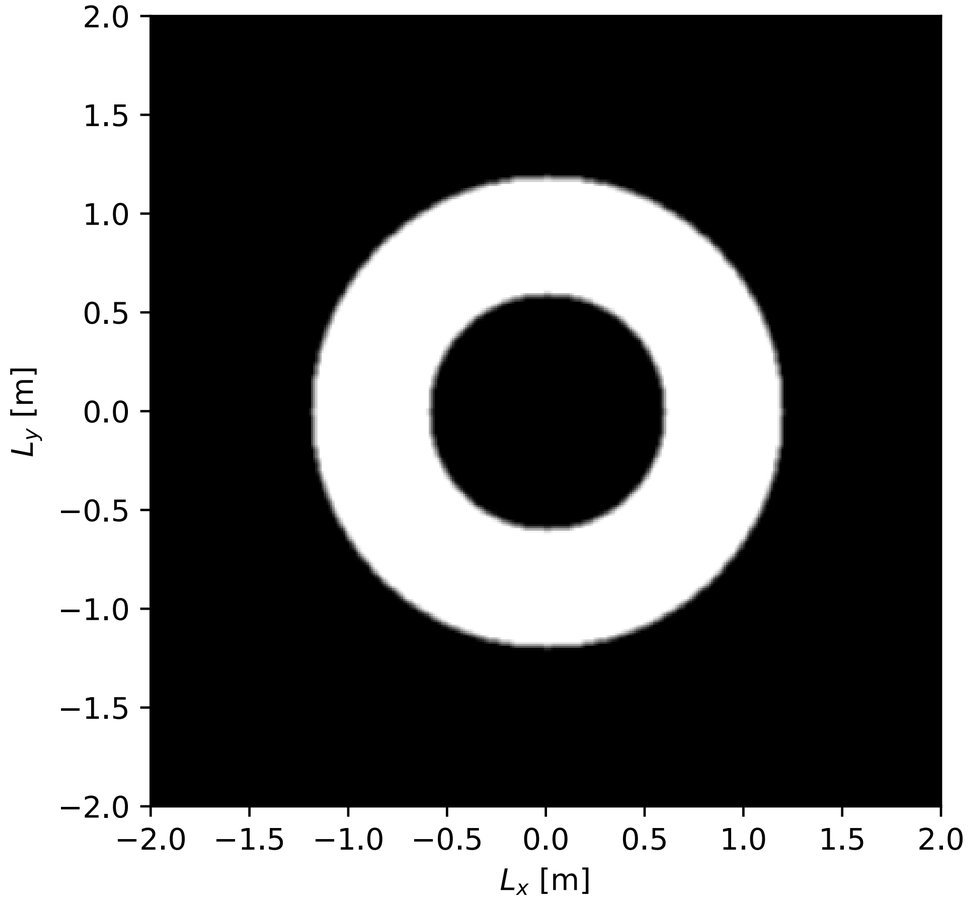
$R = 0.2 \cdot D$

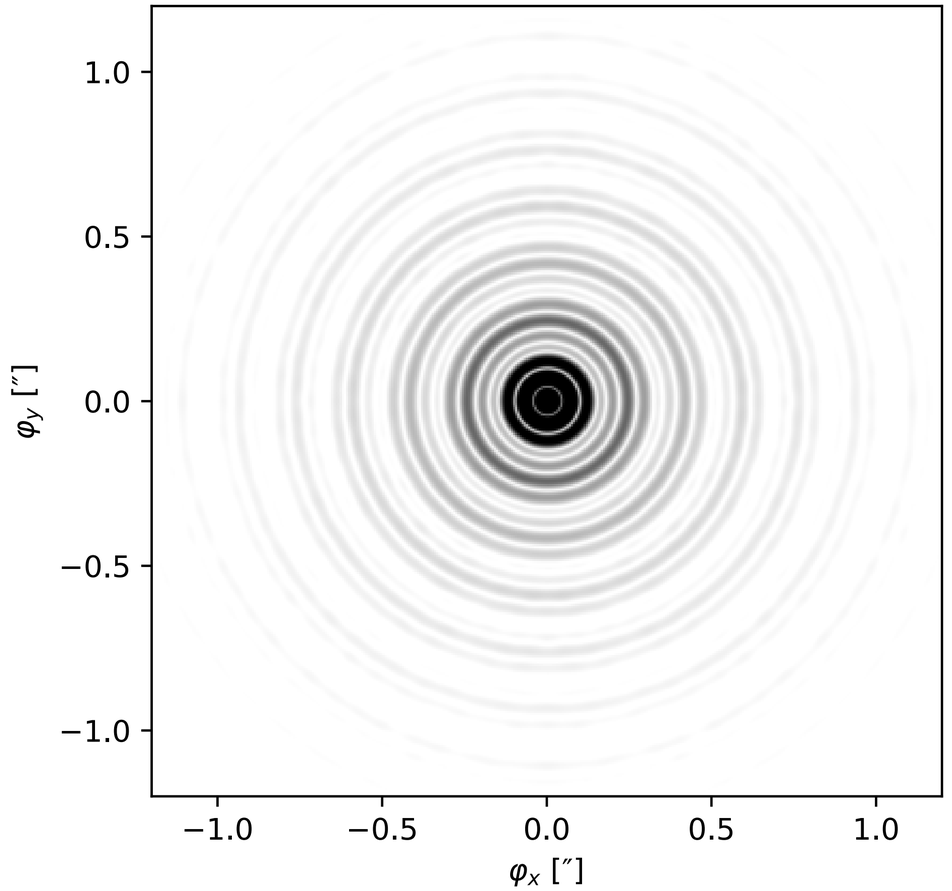




Sekundárne zrkadlo — kruhová prepážka

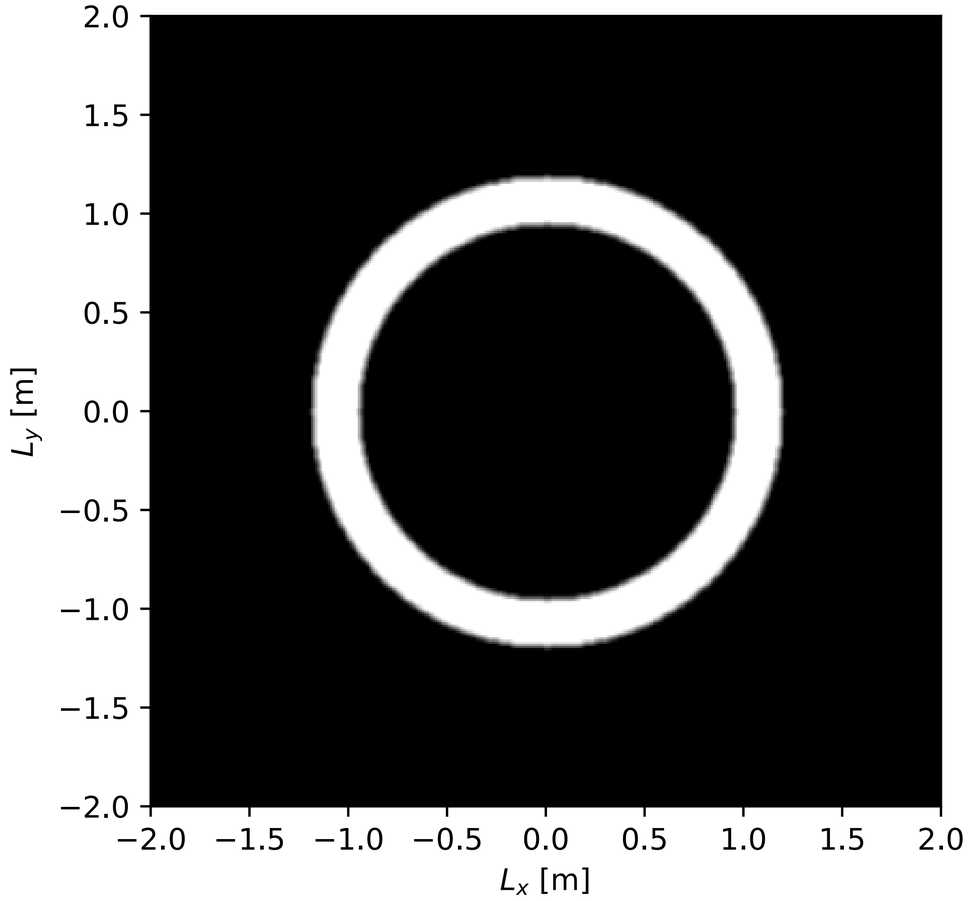
$$R = 0.5 \cdot D$$

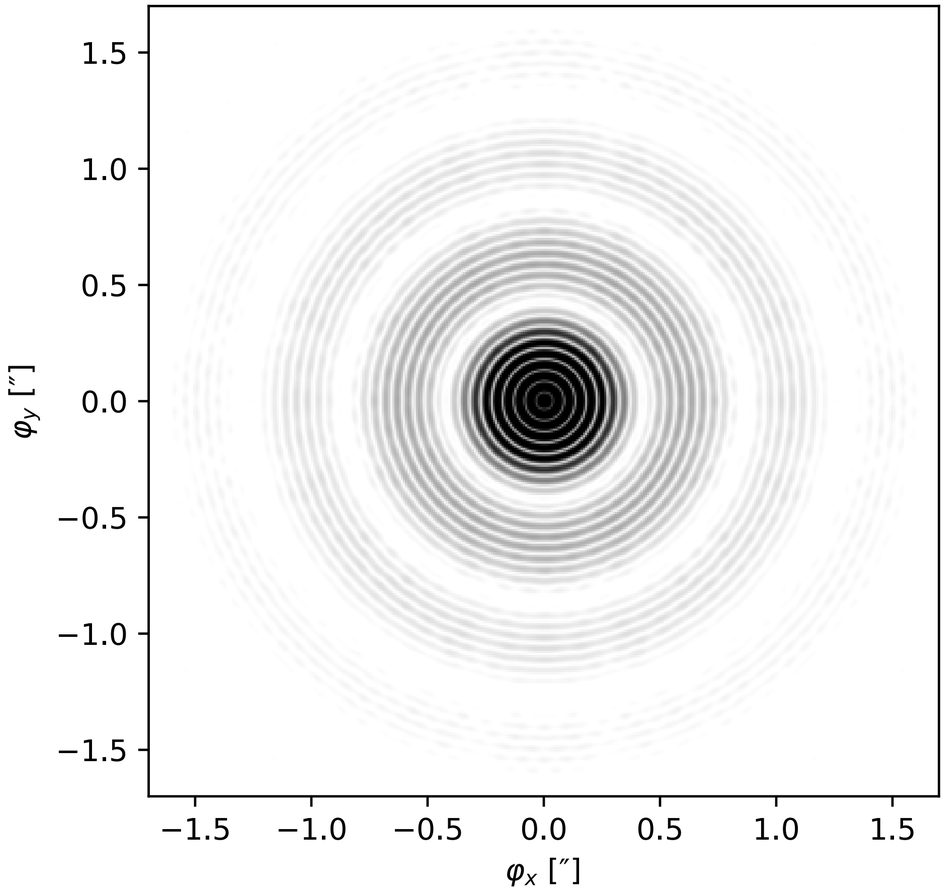




Sekundárne zrkadlo — kruhová prepážka

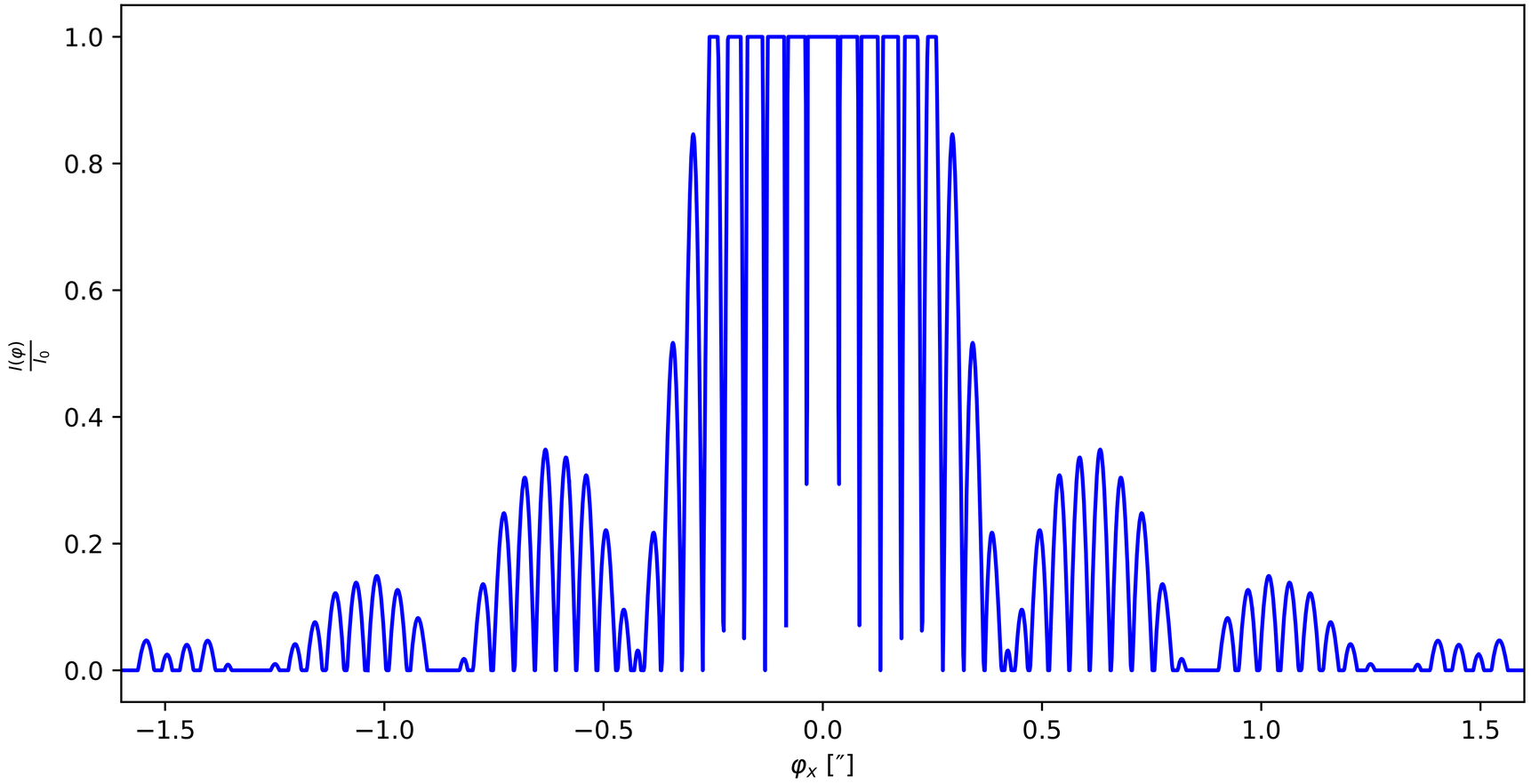
$R = 0.8 \cdot D$





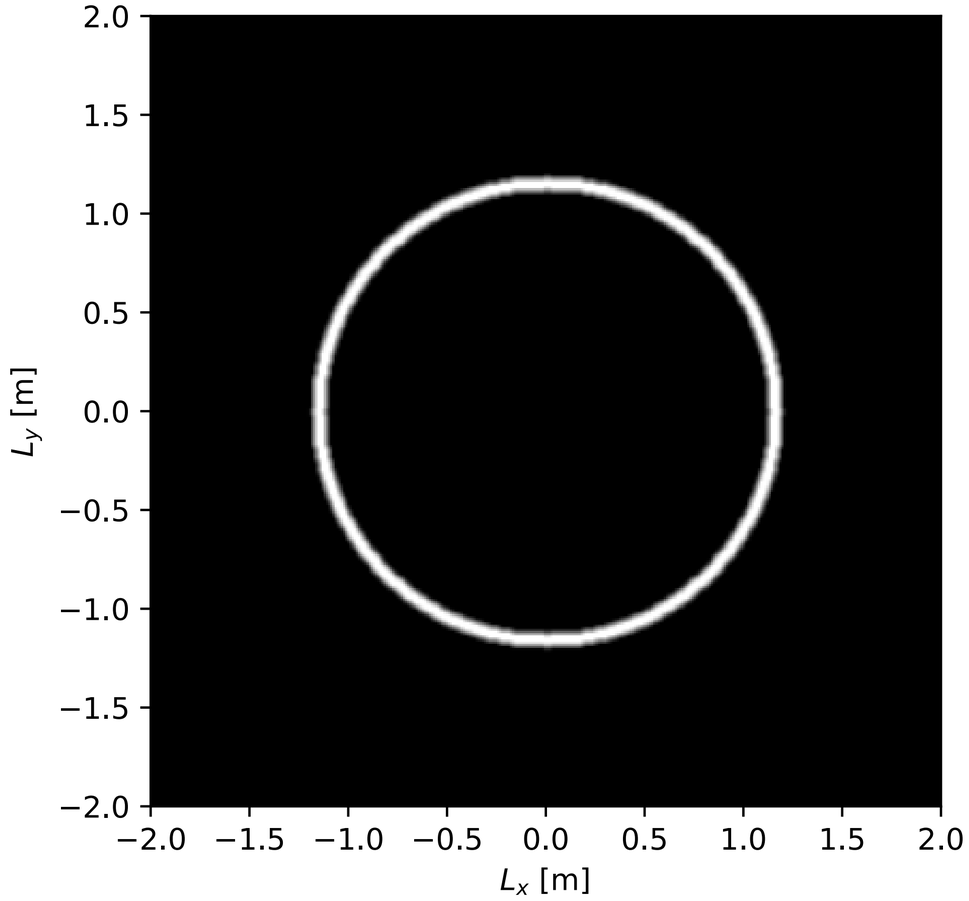
Sekundárne zrkadlo — kruhová prepážka

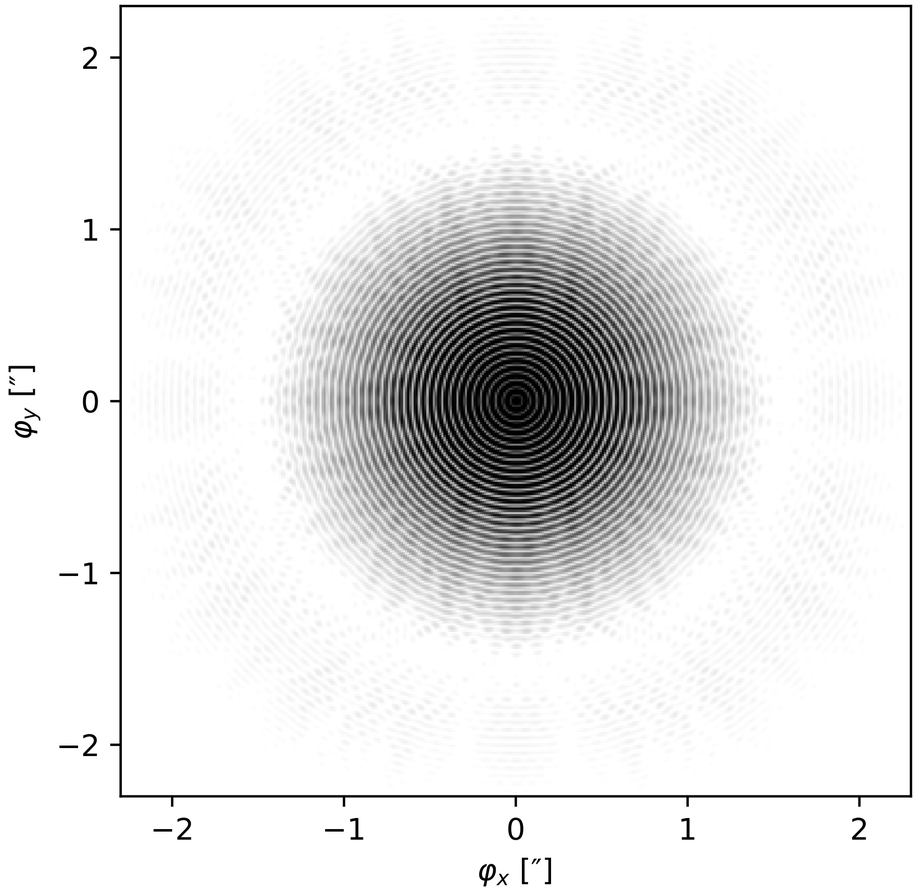
$R = 0.8 \cdot D$



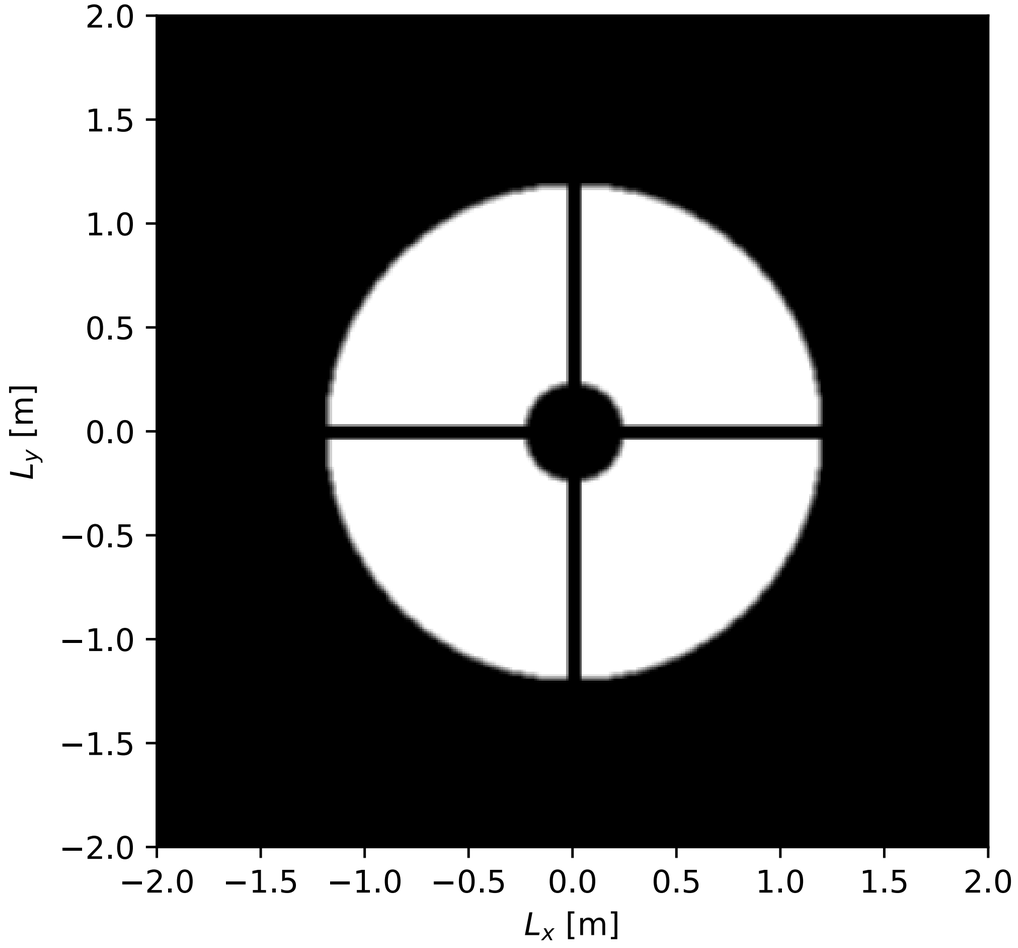
Sekundárne zrkadlo — kruhová prepážka

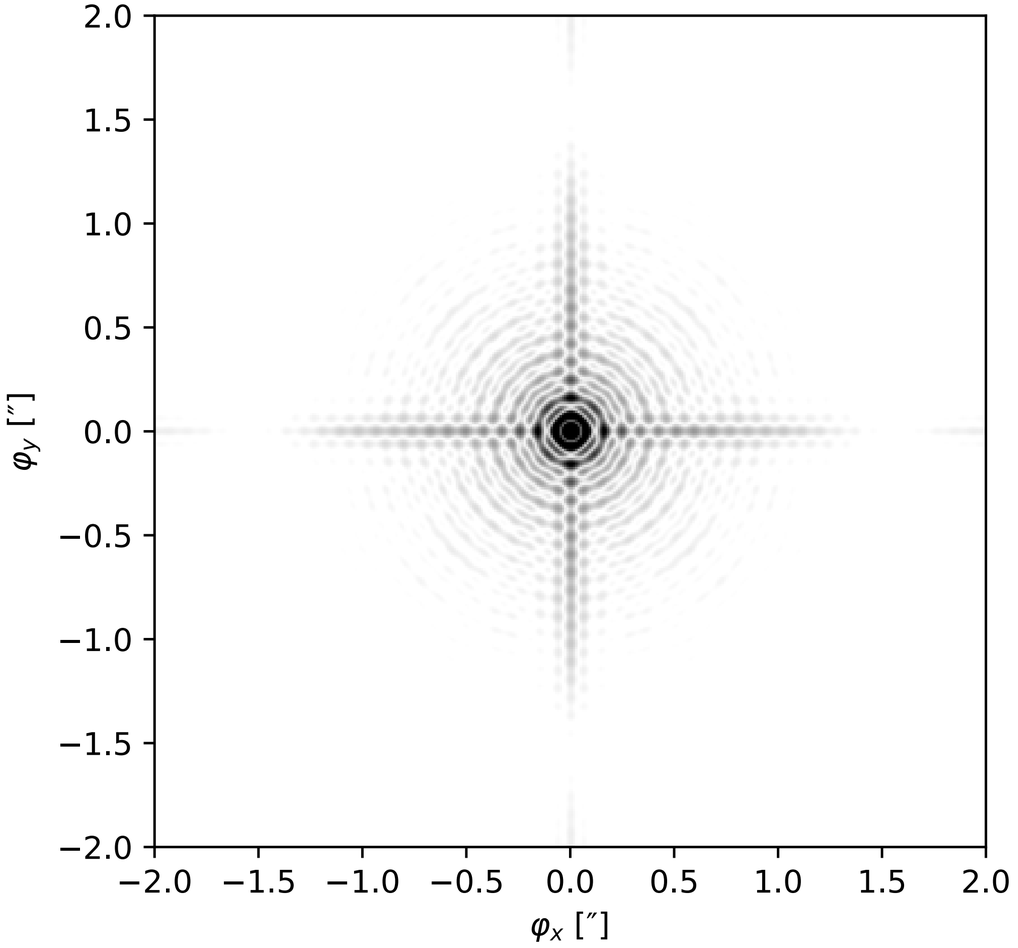
$$R = 0.95 \cdot D$$

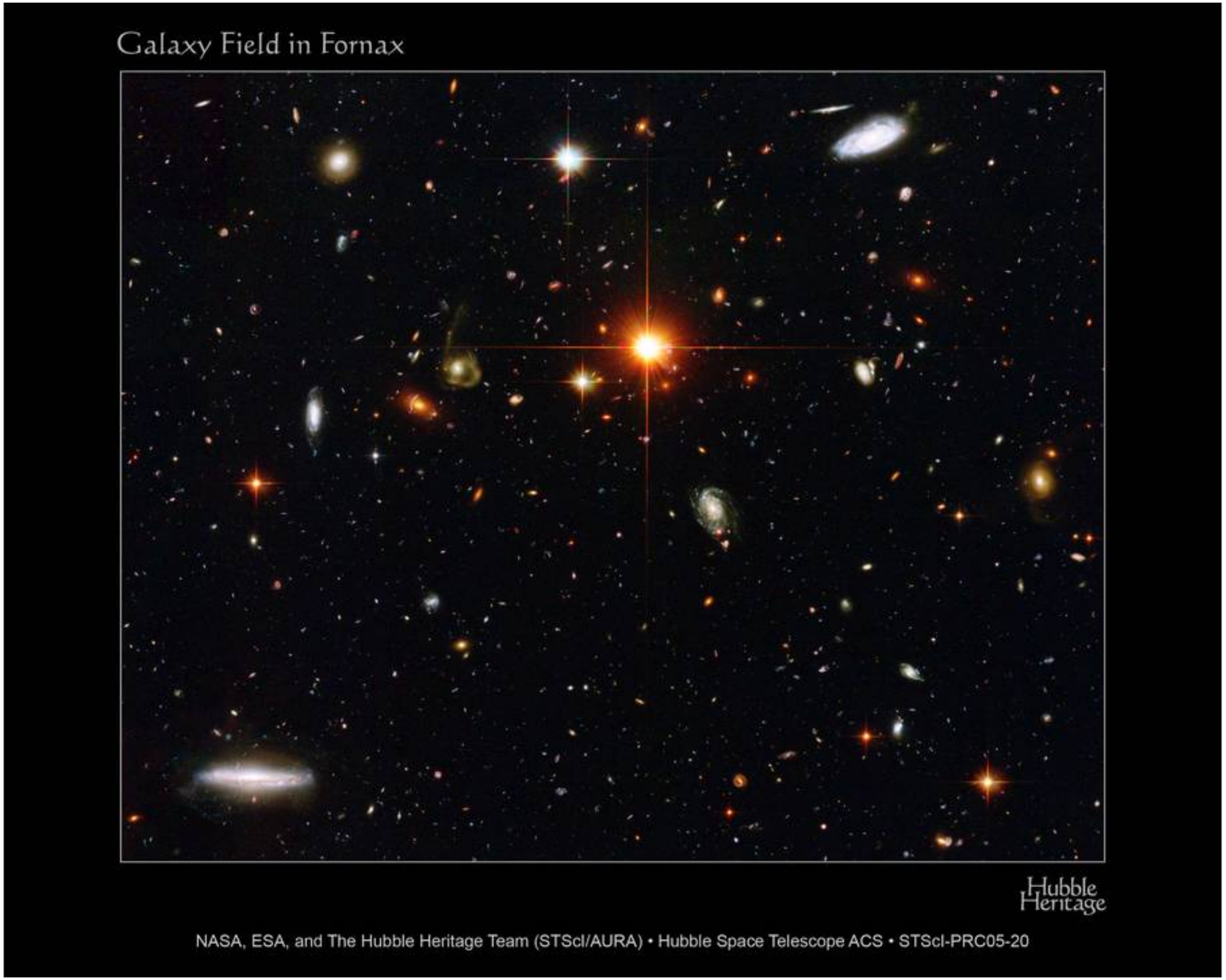




Štvorramenný držiak sekundárneho zrkadla






Galaxy Field in Fornax
Hubble Heritage
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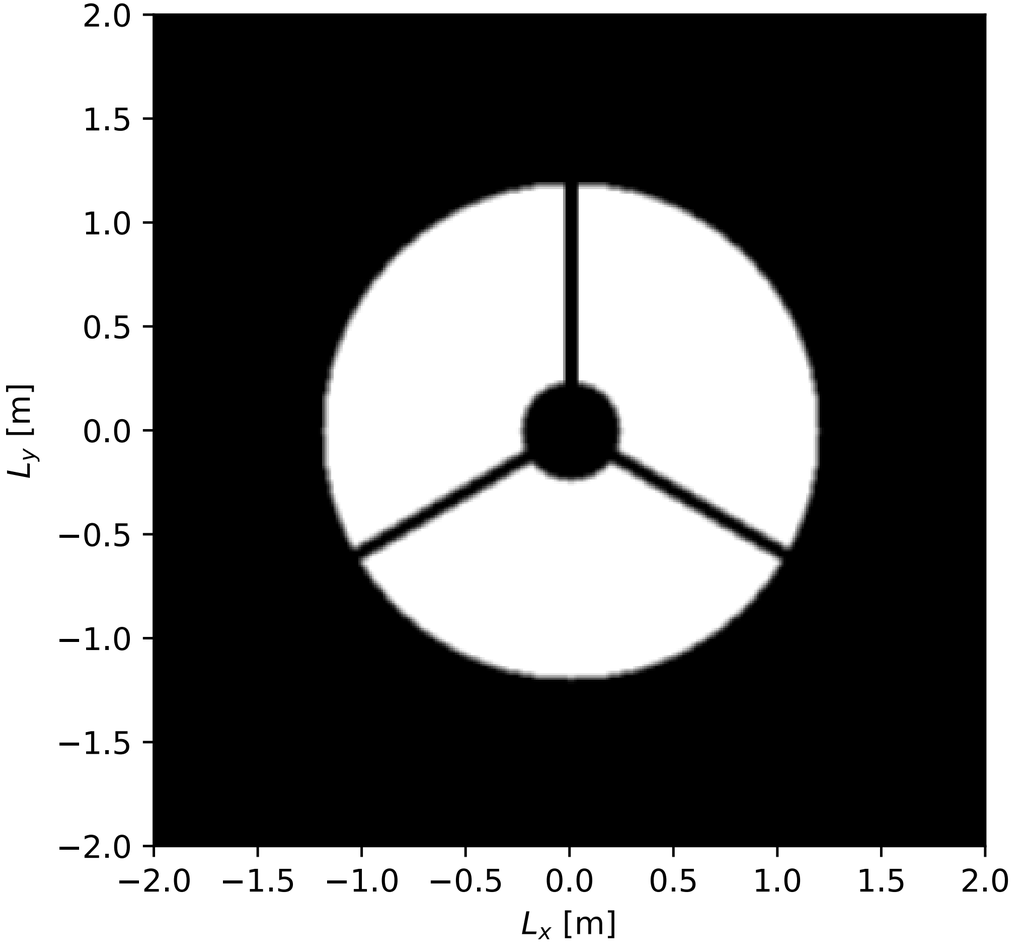
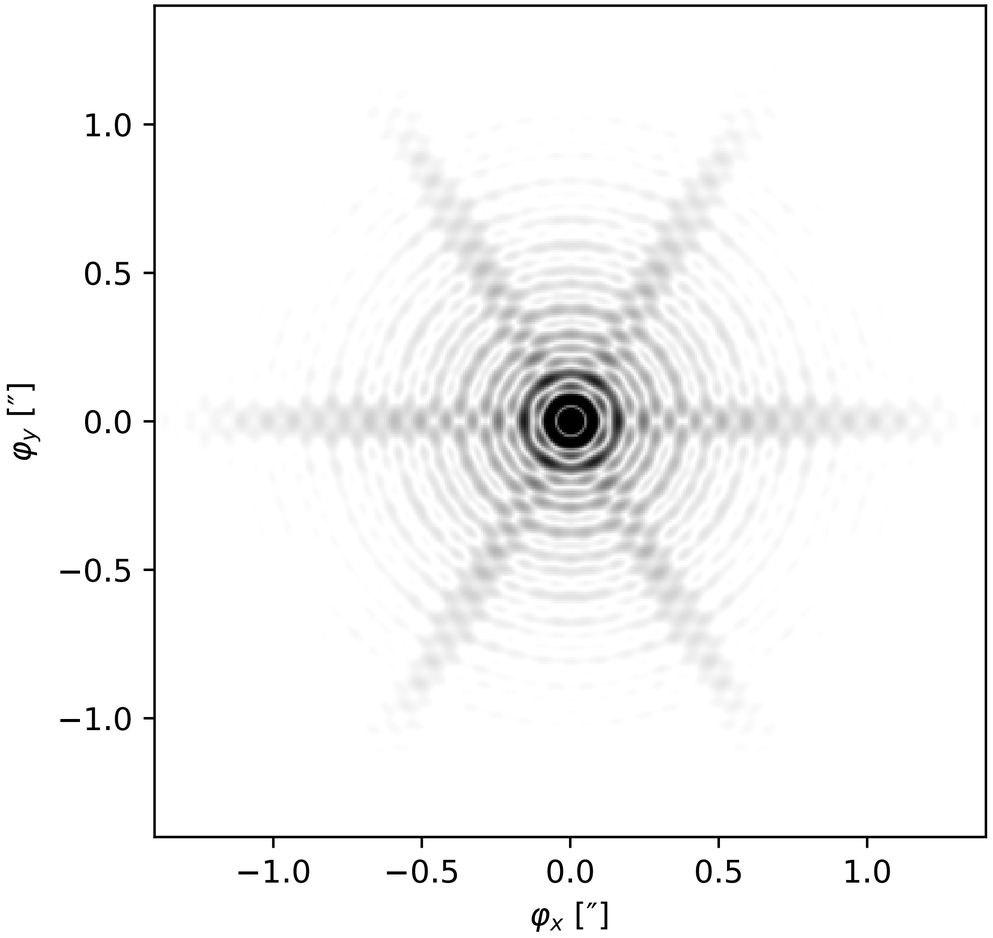
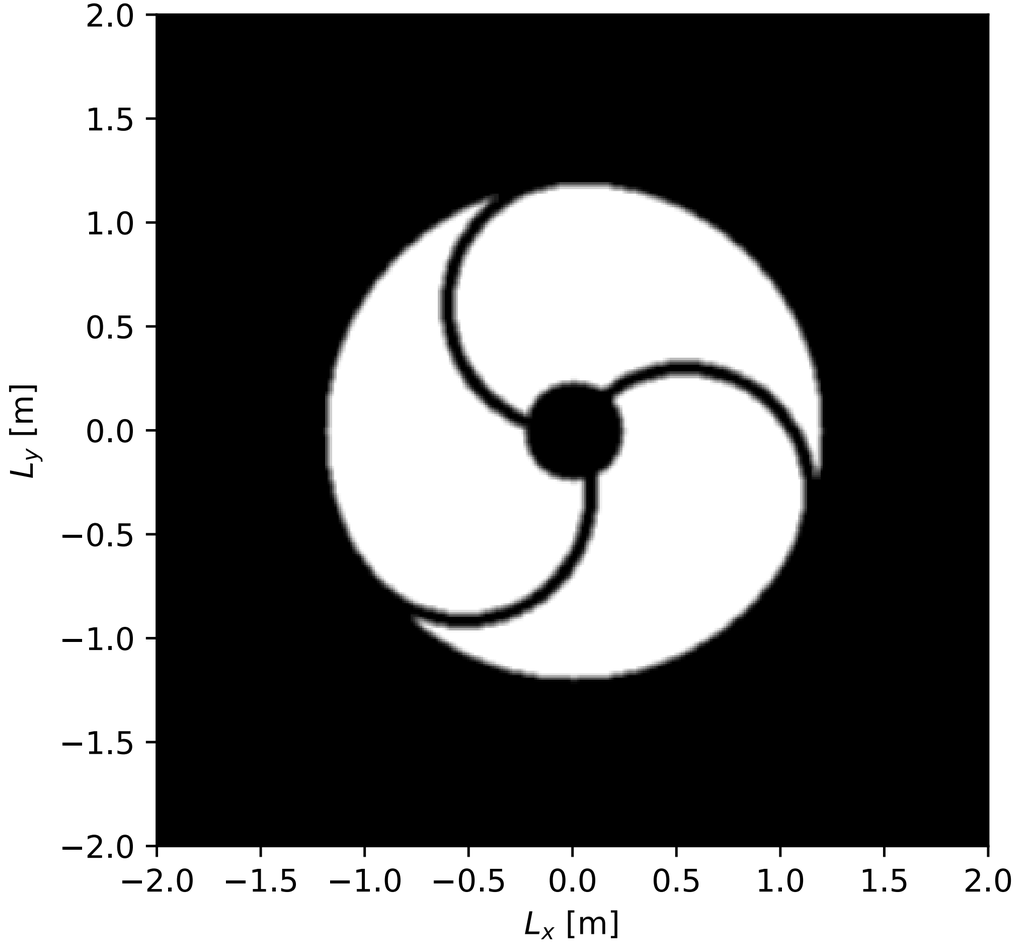
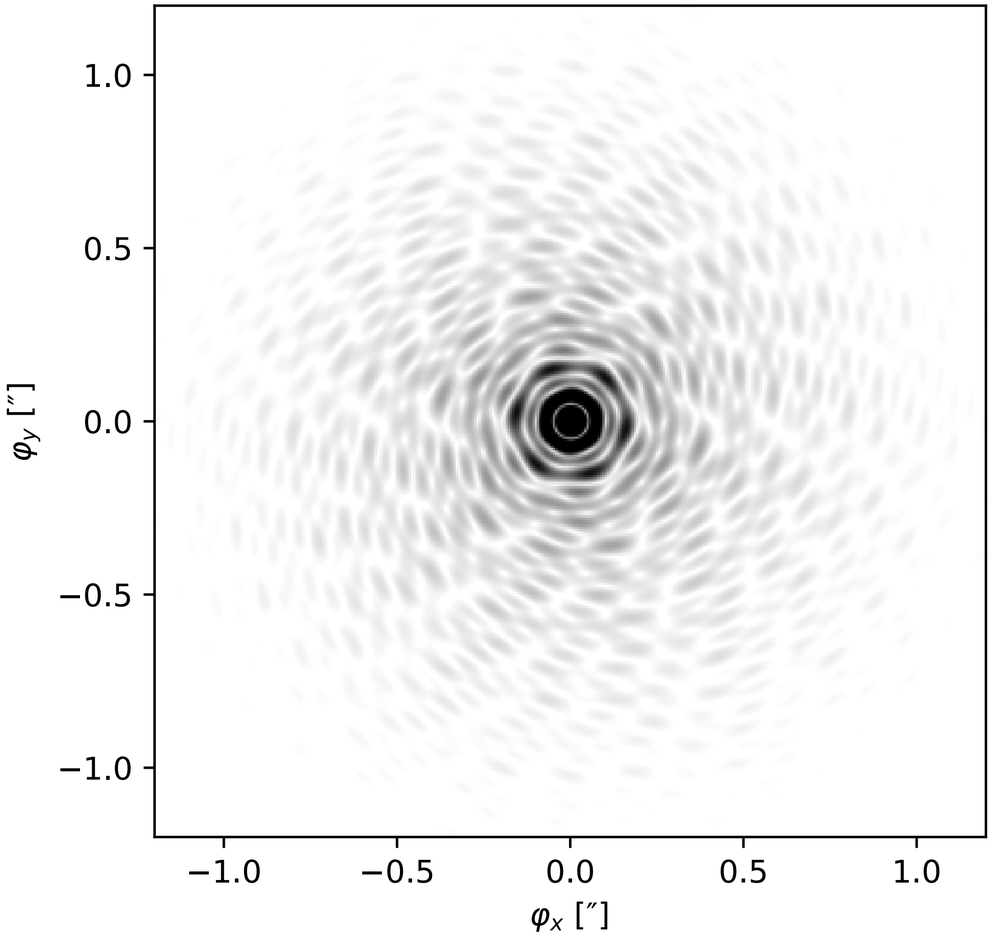
Trojramenný držiak sekundárneho zrkadla





Trojramenný držiak sekundárneho zrkadla — polkruhové ramená





Ďakujeme za pozornosť.