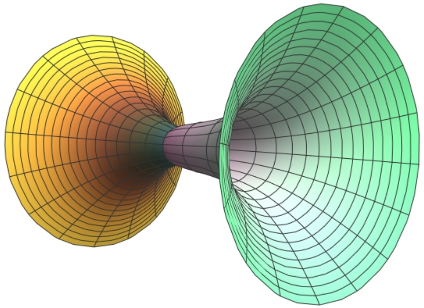

Spectral lines of asymmetric wormholes

Renan Batalha Magalhães

RBM, A. S. Masó-Ferrando, G. J. Olmo, and L. C. B. Crispino, PRD 108, 024063 (2023).

VI Amazonian Symposium on Physics
Belém, 19/11/2024

Wormholes in brief

JULY 1, 1935 PHYSICAL REVIEW VOLUME 48

The Particle Problem in the General Theory of Relativity

A. EINSTEIN AND N. ROSEN, *Institute for Advanced Study, Princeton*

(Received May 8, 1935)

TRAVERSABLE WORMHOLES FROM SURGICALLY MODIFIED SCHWARZSCHILD SPACETIMES

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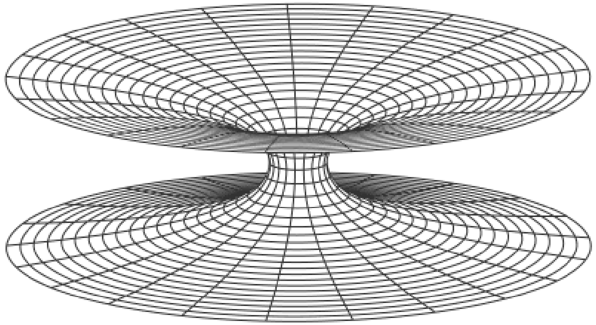
Received 27 January 1989

Traversable wormholes and light rings

Sérgio V. M. C. B. Xavier, Carlos A. R. Herdeiro, and Luís C. B. Crispino

Phys. Rev. D **109**, 124065 – Published 27 June 2024



Asymmetric RN wormholes in Palatini gravity

$$\mathcal{S} = \frac{1}{2\kappa^2}\int d^4x\sqrt{-g}f(\mathcal{R}) + \int d^4x\sqrt{-g}\mathcal{L}_m(g_{\mu\nu},\psi_m)$$

Junction conditions

Class. Quant. Grav. 37, 215002 (2020).

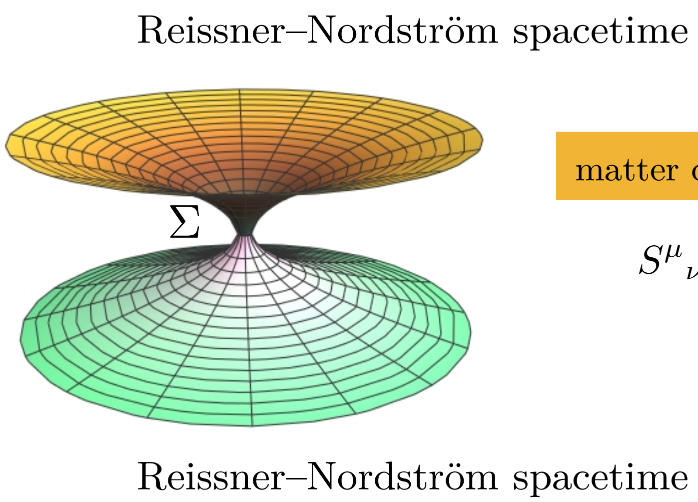
$$[g_{\mu\nu}] = 0,$$

$$\frac{1}{3}h_{\mu\nu}[K^\rho_\rho] - [K_{\mu\nu}] = \kappa^2\frac{S_{\mu\nu}}{f_{\mathcal{R}|_\Sigma}},$$

$$[T] = 0 \text{ and } S = 0,$$

$$D^\rho S_{\rho\nu} = -n^\rho h^\sigma_\nu [T_{\rho\sigma}],$$

$$\left(K^+_{\rho\sigma} + K^-_{\rho\sigma}\right) S^{\rho\sigma} = 2n^\rho n^\sigma [T_{\rho\sigma}] - \frac{3\mathcal{R}_T^2 f_{\mathcal{R}\mathcal{R}}^2}{f_\mathcal{R}}[b^2]$$

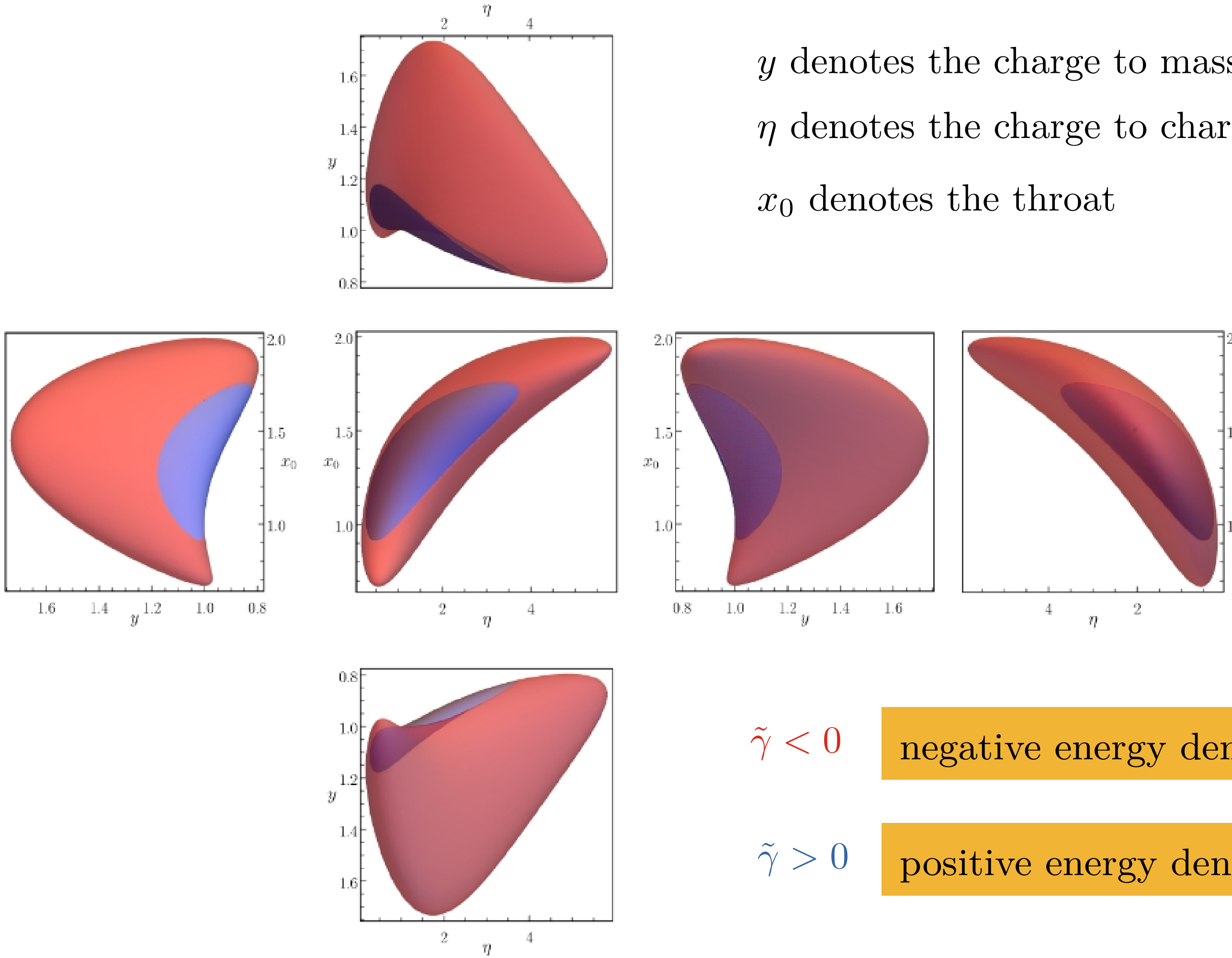


matter content of the thin shell

$$S^\mu{}_\nu = \text{diag}(-\sigma,\mathcal{P},\mathcal{P}),$$

$$\mathcal{P} = \frac{\sigma}{2}$$

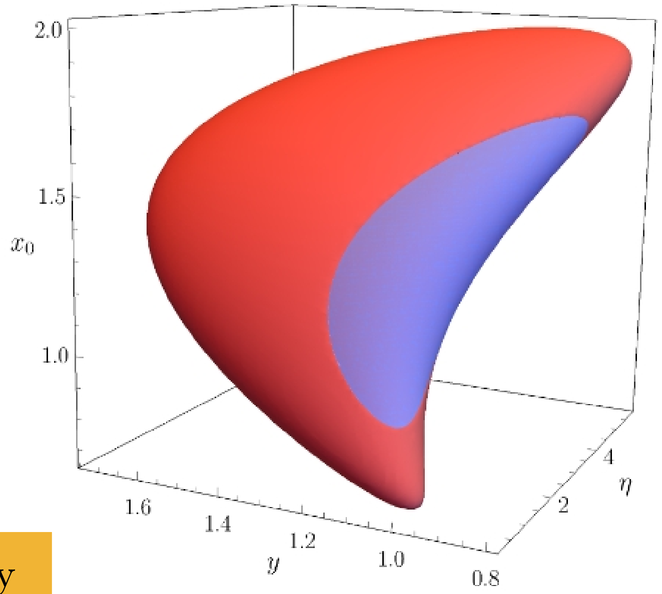
Parameter space



y denotes the charge to mass ratio in $\mathcal{M}_{-}$

η denotes the charge to charge ratio

x_0 denotes the throat



$\tilde{\gamma} < 0$ negative energy density

$\tilde{\gamma} > 0$ positive energy density

Wave equation

Let us consider a massless scalar field lying in a RN-AWH background

$$\Box_{\pm}\Phi_{\pm} = 0,\ [\Phi] = 0,\ n^{\mu}[\nabla_{\mu}\Phi] = 0$$

$$f_{\pm}(x_{\pm})\frac{d}{dx_{\pm}}\left(f_{\pm}(x_{\pm})\frac{d\psi_{\pm}}{dx_{\pm}}\right) + \left(\tilde{\omega}^2 - \tilde{V}_{\pm}(x_{\pm})\right)\psi_{\pm} = 0,$$

$$\tilde{V}_{\pm}(x_{\pm}) = \frac{f_{\pm}(x_{\pm})}{x_{\pm}}\frac{df_{\pm}}{dx_{\pm}} + \frac{f_{\pm}(x_{\pm})}{x_{\pm}^2}\ell(\ell+1)$$

No delta-type contribution on the effective potential!

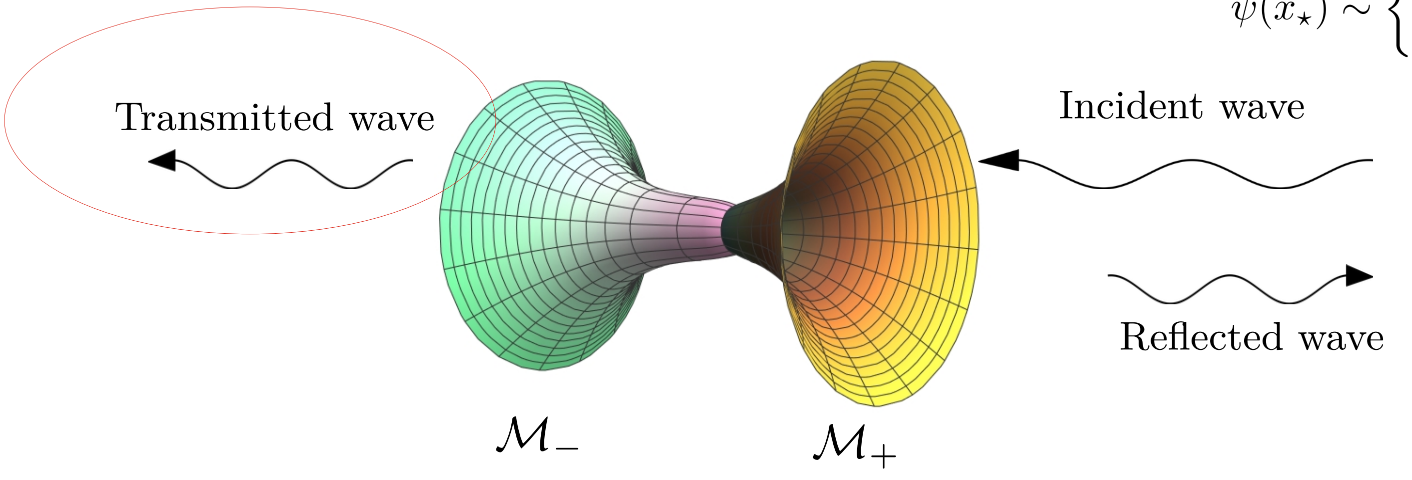
$$dx_{\star} = \pm\frac{dx_{\pm}}{f_{\pm}(x_{\pm})}$$

throat

$x_{\star} \to -\infty$ $\quad x_{\star} = 0 \quad$ $x_{\star} \to \infty$

Scalar absorption

$$\psi(x_\star) \sim \begin{cases} e^{-i\tilde{\omega}x_\star} + \mathcal{R}_{\tilde{\omega}\ell} e^{i\tilde{\omega}x_\star}, & x_\star \to +\infty, \\ \mathcal{T}_{\tilde{\omega}\ell} e^{-i\tilde{\omega}x_\star}, & x_\star \to -\infty. \end{cases}$$



The (dimensionless) total scalar absorption cross section of RN and RN-AWHs

$$\tilde{\sigma}_{\rm abs} = \sum_{\ell=0}^{\infty} \tilde{\sigma}_\ell, \quad \tilde{\sigma}_\ell \equiv \pi(2\ell+1)|\mathcal{T}_{\tilde{\omega}\ell}|^2/\tilde{\omega}^2$$

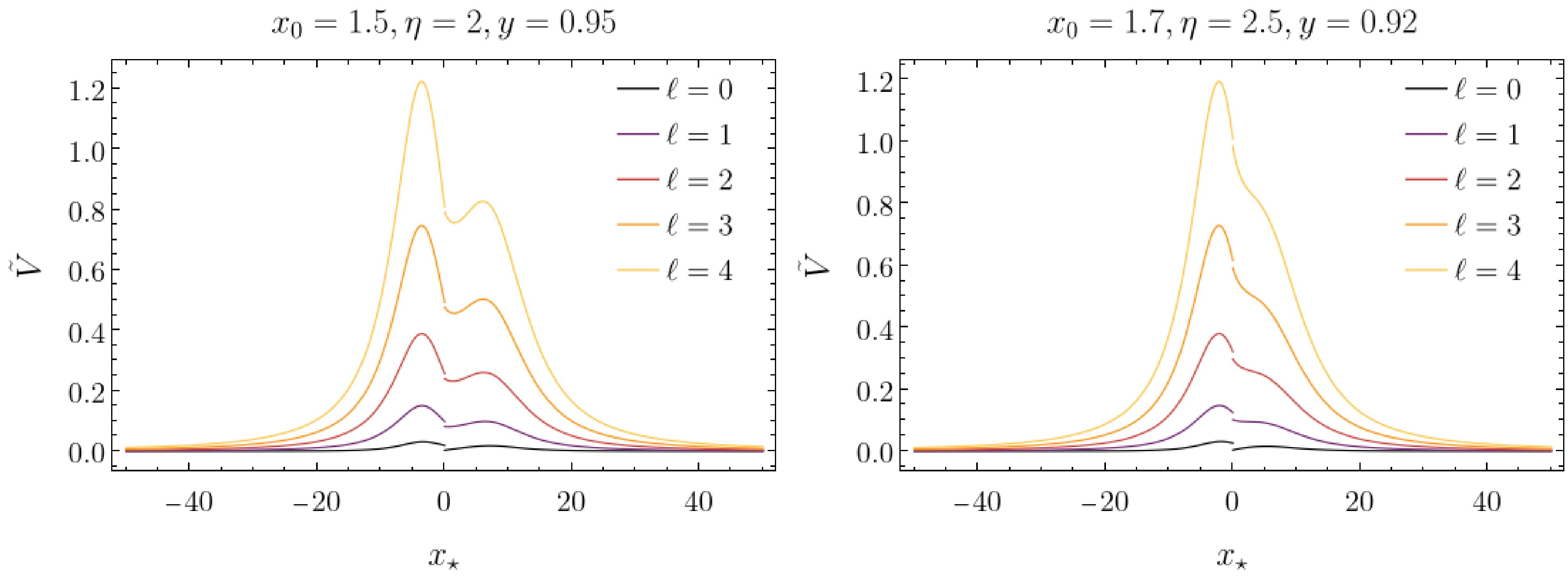
For black holes, there are two well-known limits

For wormholes, these limits are not so clear

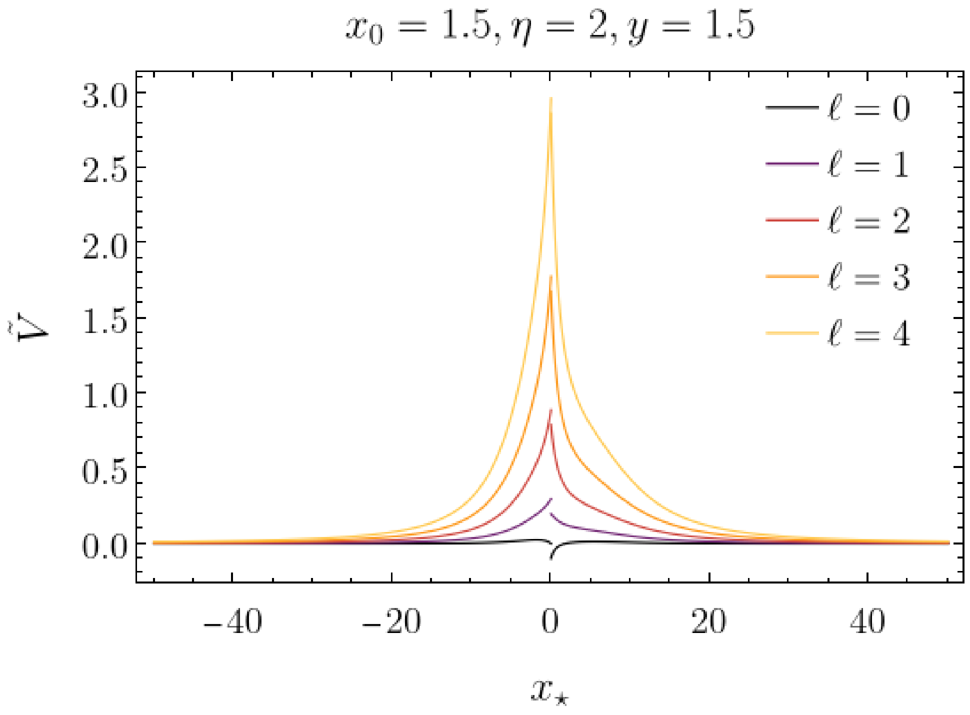
$\tilde{\omega} \to 0, \quad \tilde{\sigma}_{\rm abs} \to$ event horizon area

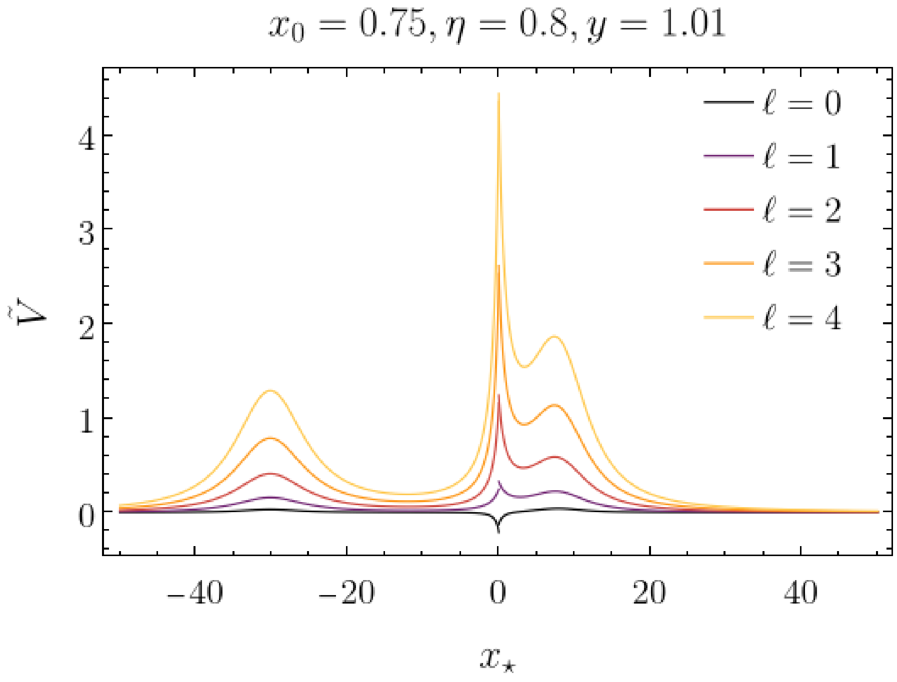
$\tilde{\omega} \to \infty, \quad \tilde{\sigma}_{\rm abs} \to$ oscillates around the classical absorption cross section

Effective potential

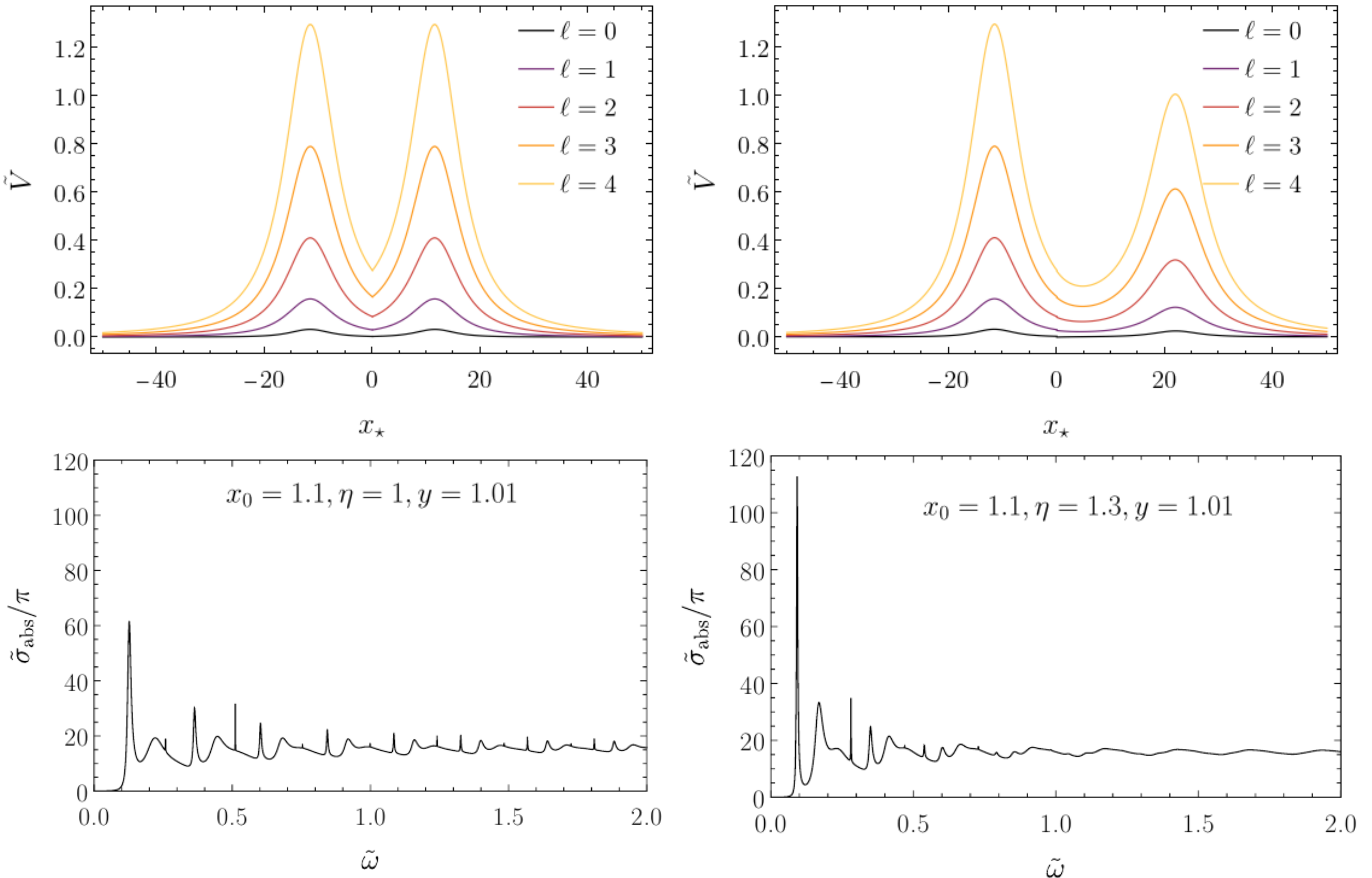


Effective potential

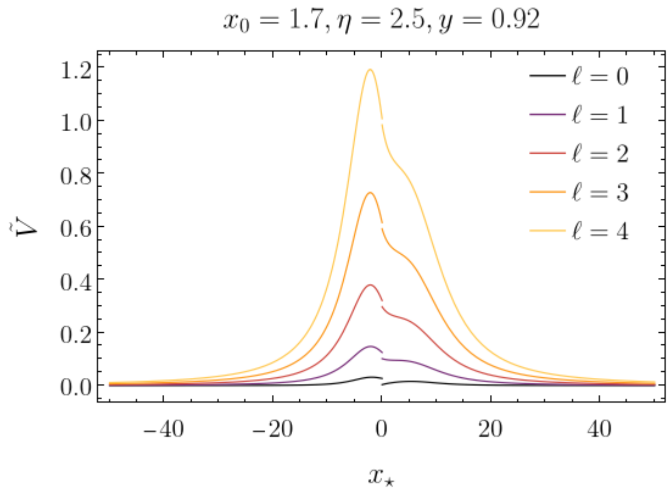


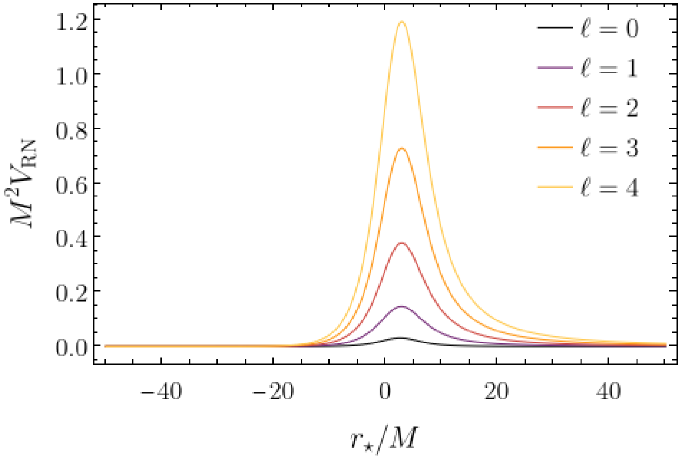


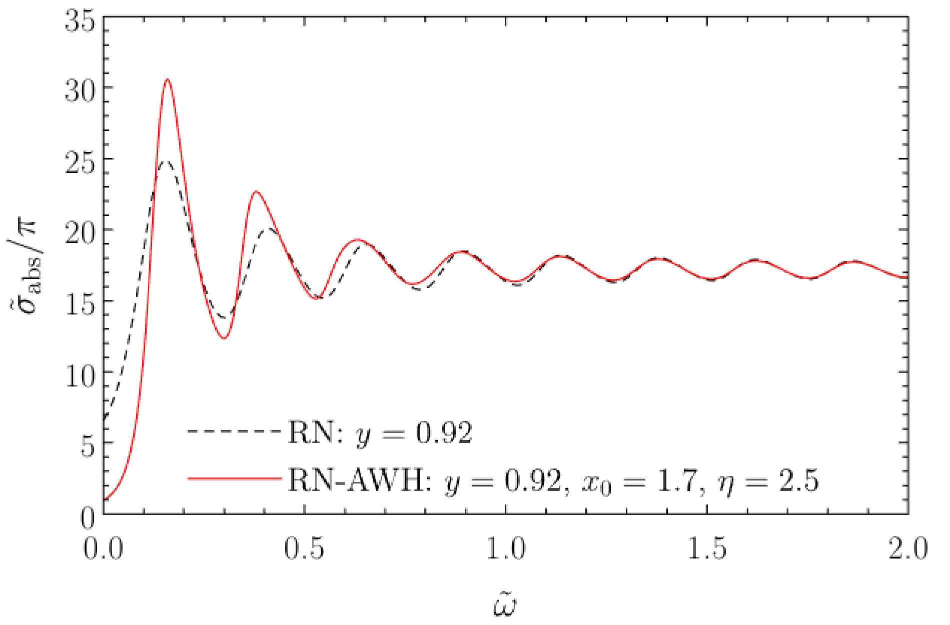
Asymmetric valleys



Black holes versus asymmetric wormholes







Acknowledgement