Transport barriers in the drift wave model

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Drift wave model

The drift wave model assumes that the motion of confined plasma particles is influenced by the drift **E** × **B**, in which the electric field has a fluctuating component referring to the electrostatic fluctuations defined as:

$$\tilde{\phi}(\mathbf{x}, t) = \sum_{m,l,n} \phi_{m,l} \cos(m\vartheta - l\varphi - n\omega_0 t). \tag{1}$$

Assuming two dominant spatial modes, (M, L) and $(M+1, L)$, the resultant map can be described as follows

$$I_{n+1} = I_n + \alpha_1 \sin(\chi_n) + \alpha_2 \sin(\chi_n + \varphi_n), \tag{2a}$$

$$\chi_{n+1} = \chi_n + \tilde{\beta}\left[\frac{v_{||}(I)}{q(I)R}[M - Lq(I)] - \frac{ME_0(I)}{aB\sqrt{I_{n+1}}}\right], \tag{2b}$$

$$\varphi_{n+1} = \varphi_n + \frac{2\pi v_{||}(I)}{\omega_0 a\sqrt{I_{n+1}}}, \tag{2c}$$

Plasma Profiles

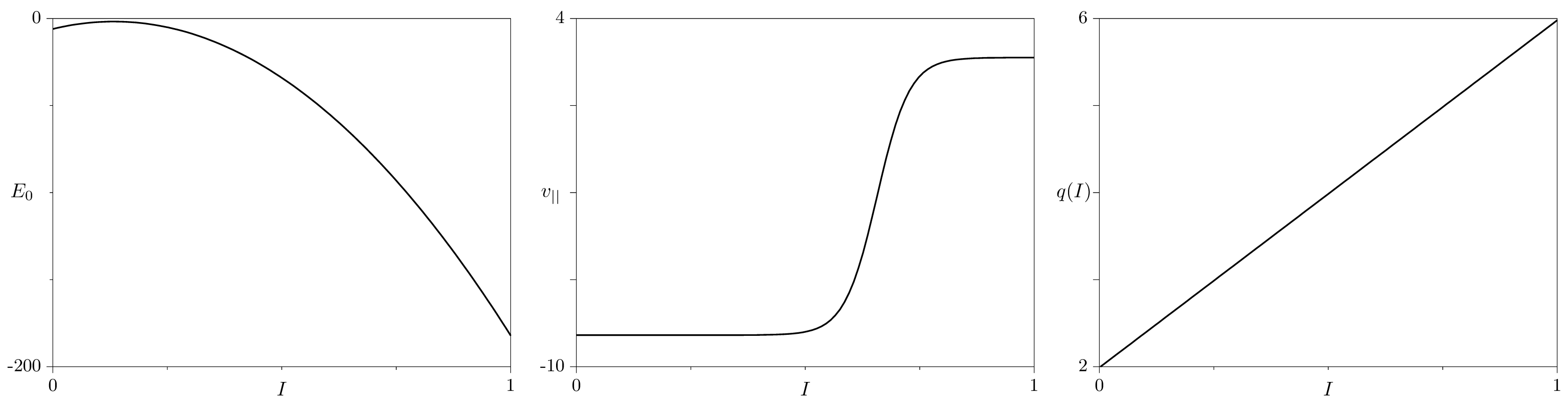

Figure 1. Plasma profiles used. In (a) Equilibrium electric field, (b) parallel velocity and (c) safety factor

Shearless transport barrier

The extremum point in the winding number profile $\Omega(I)$ identifies a condition of the shearless barrier.

$$\Omega = \lim_{n\to\infty} \frac{\chi_{n+1} - \chi_0}{n}$$

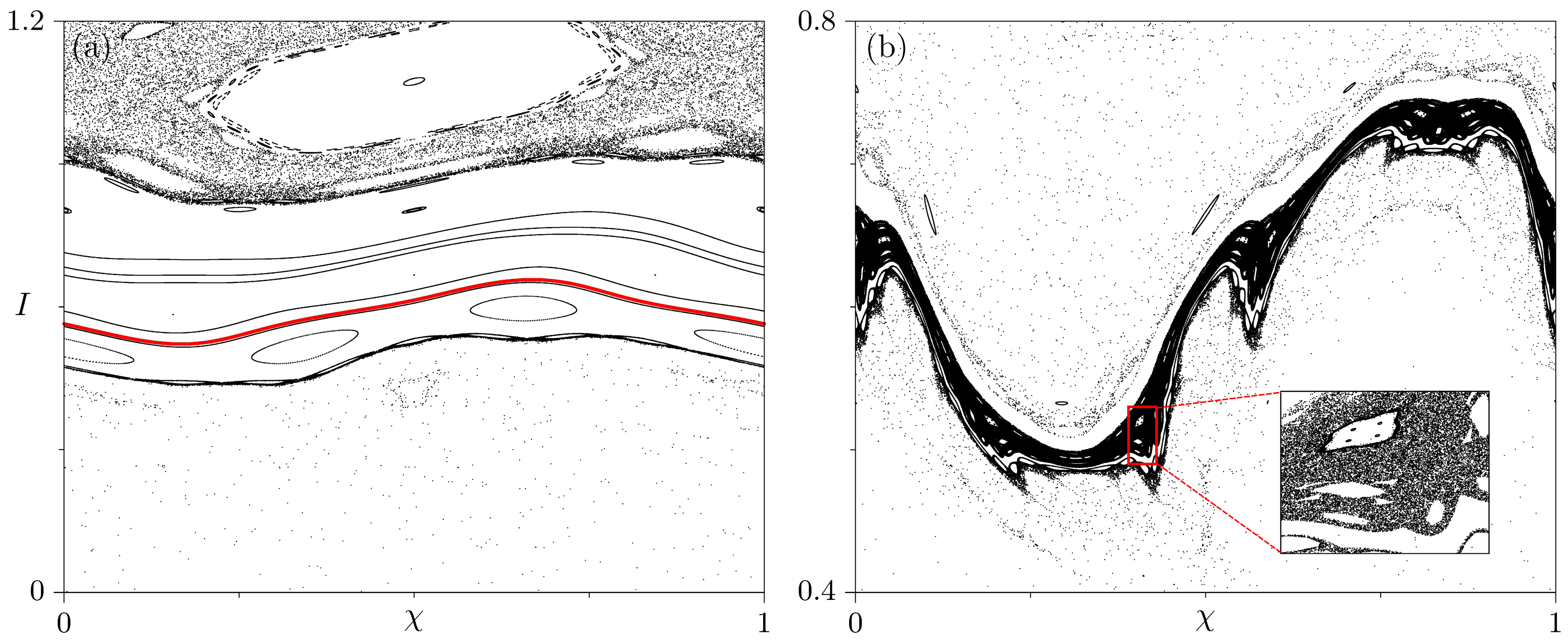

Figure 2. Phase spaces, (a) in red the shearless barrier and (b) Stickness (Partial barrier).

Main references

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[3] L. A. Osorio, M. Roberto, I. L. Caldas, R. L. Viana, and Y. Elskens, "Onset of internal transport barriers in tokamaks," *Physics of Plasmas*, vol. 28, no. 8, p. 082305, 2021.

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Particle escape time

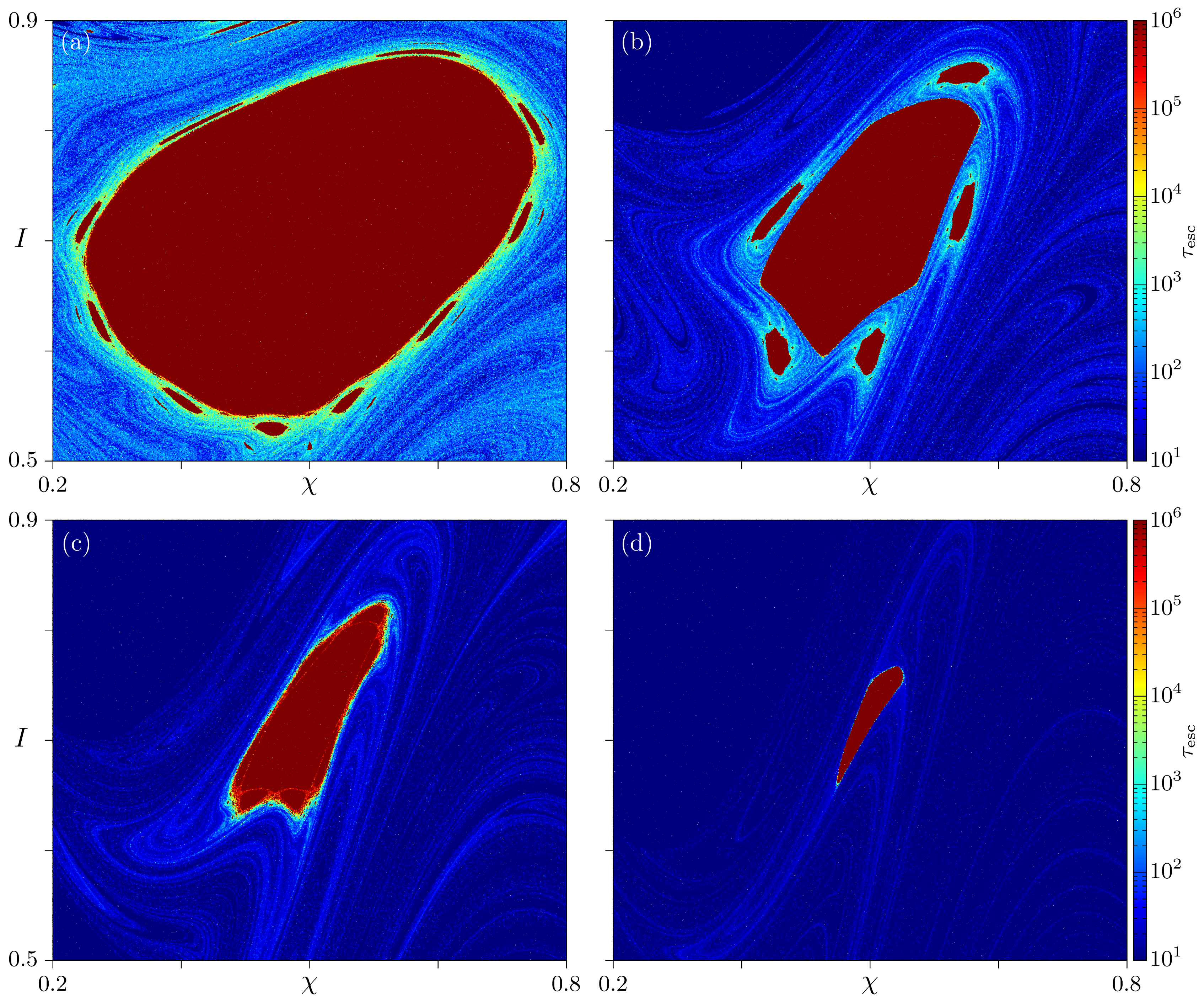

Figure 3. Particle escape. As the perturbation increases, the faster the particles escape.

Transmissivity parameter spaces

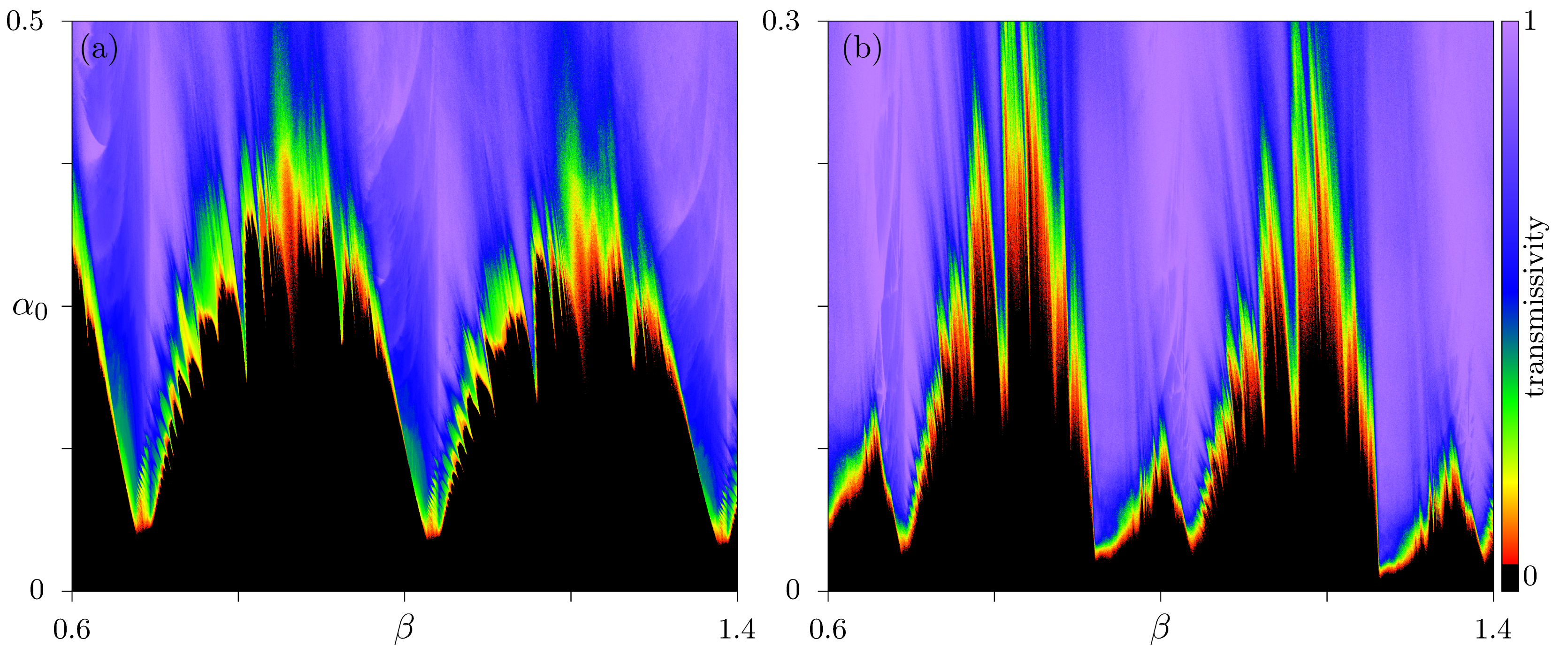

Figure 4. Transmissivity, the fraction of escaping orbits. In the black regions, there is a total barrier.

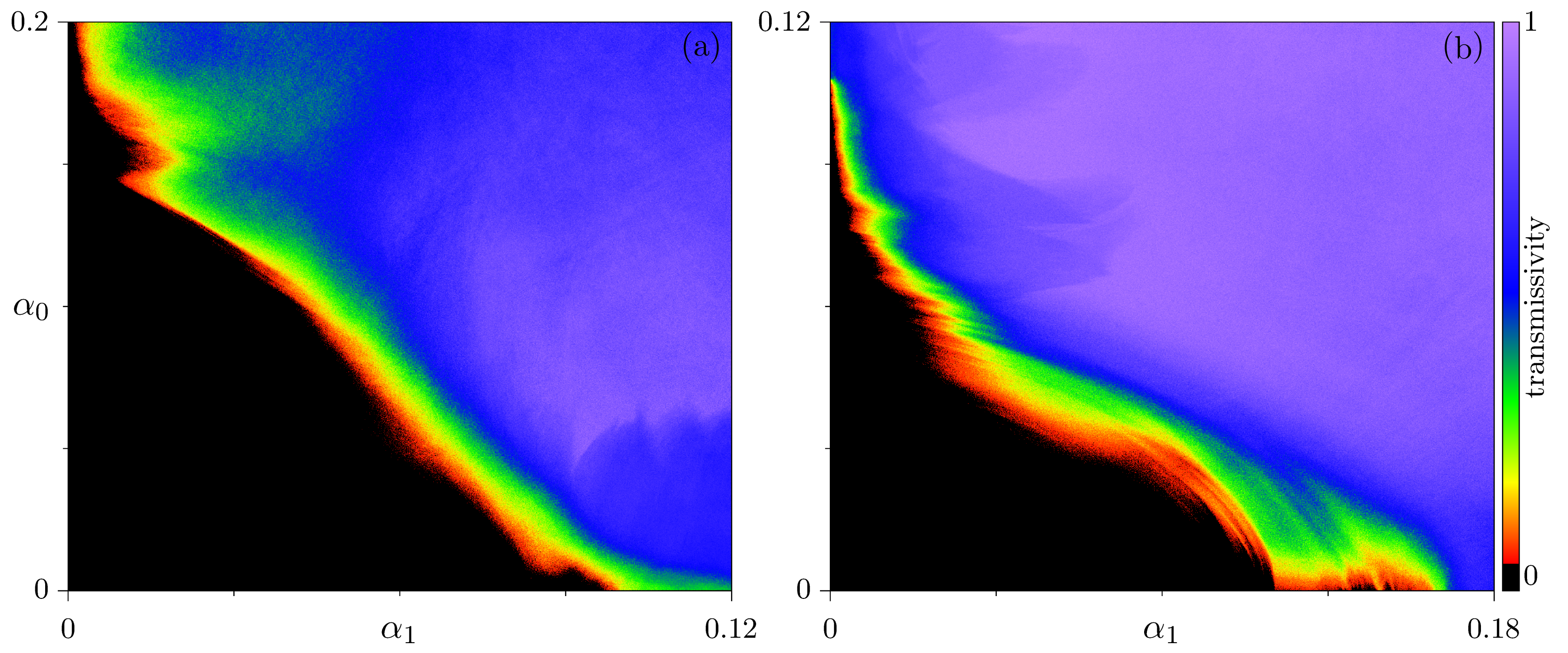

Figure 5. Transmissivity, the fraction of escaping orbits. In the black regions, there is a total barrier.

Conclusions

- For non-monotonic profile of $\mathbf{E}(I)$, the system exhibits Shearless transport barrier
- Adding other perturbative modes increases the degree of freedom
- The perturbation modes destroy the shearless barrier
- the remnants of the shearless barrier, act as partial barriers

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