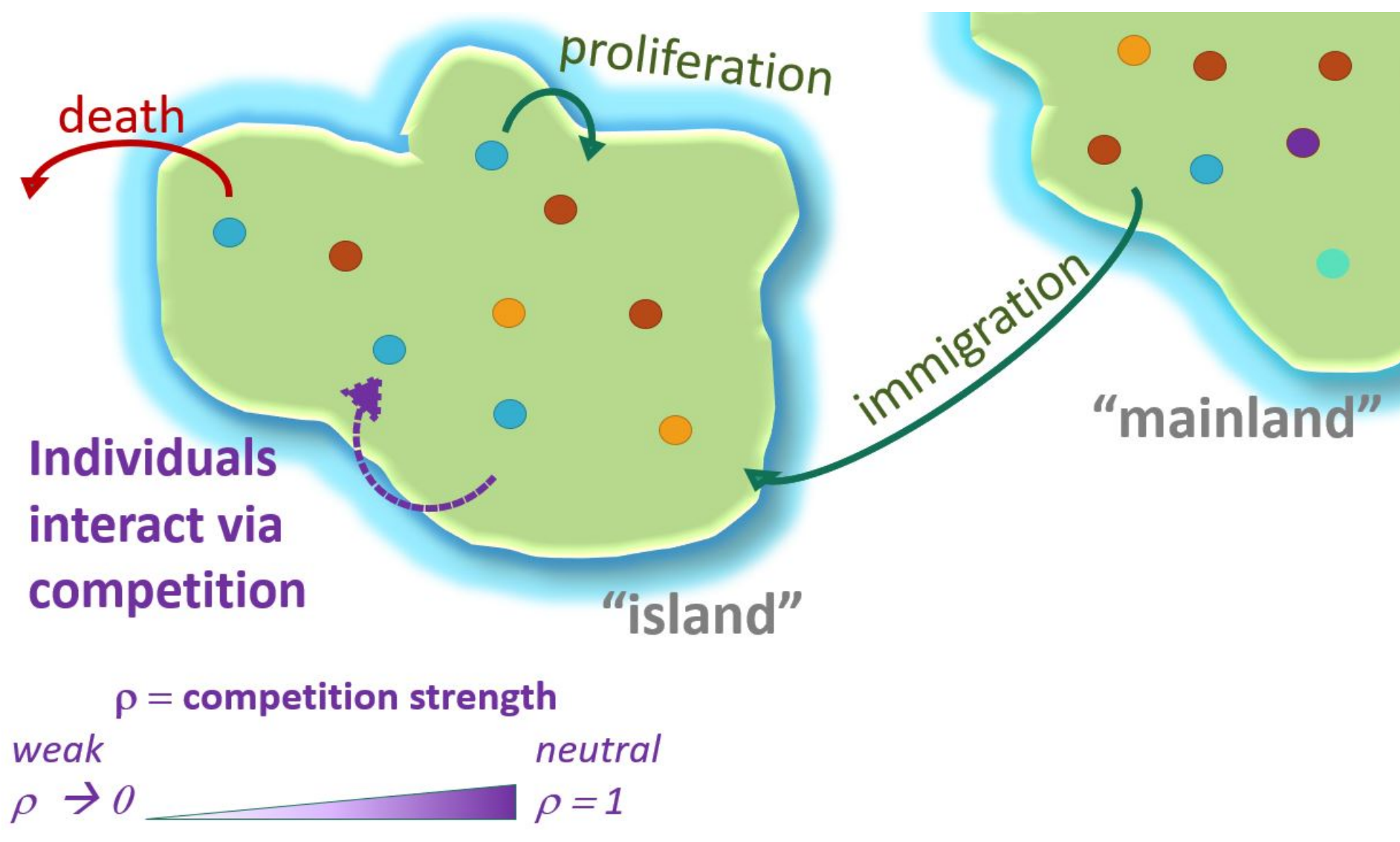


Behavior of Competitive Ecosystems Beyond the Niche-Neutral Regimes

NAVA LEIBOVICH, J. ROTHSCHILD, A. ZILMAN, S. GOYAL

Department of Physics, University of Toronto, Canada

MODEL

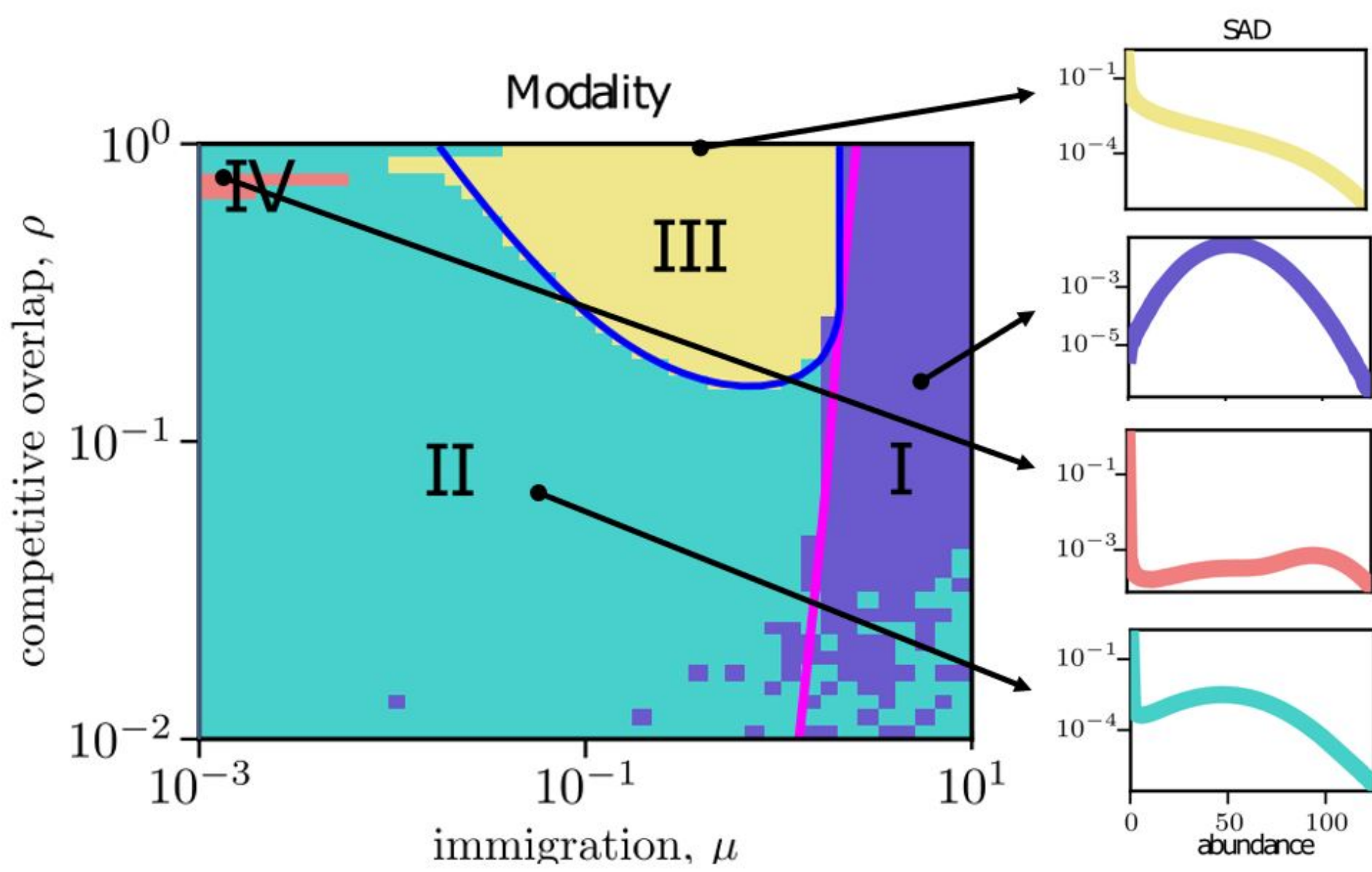


- Competition - due to limited resources → may reduce species population
- Immigration from 'mainland' → add individuals
- symmetric interactions
- long-time limit → stationarity
- Stochastic discrete process.

MODALITY

different behavior of $P(n)$:

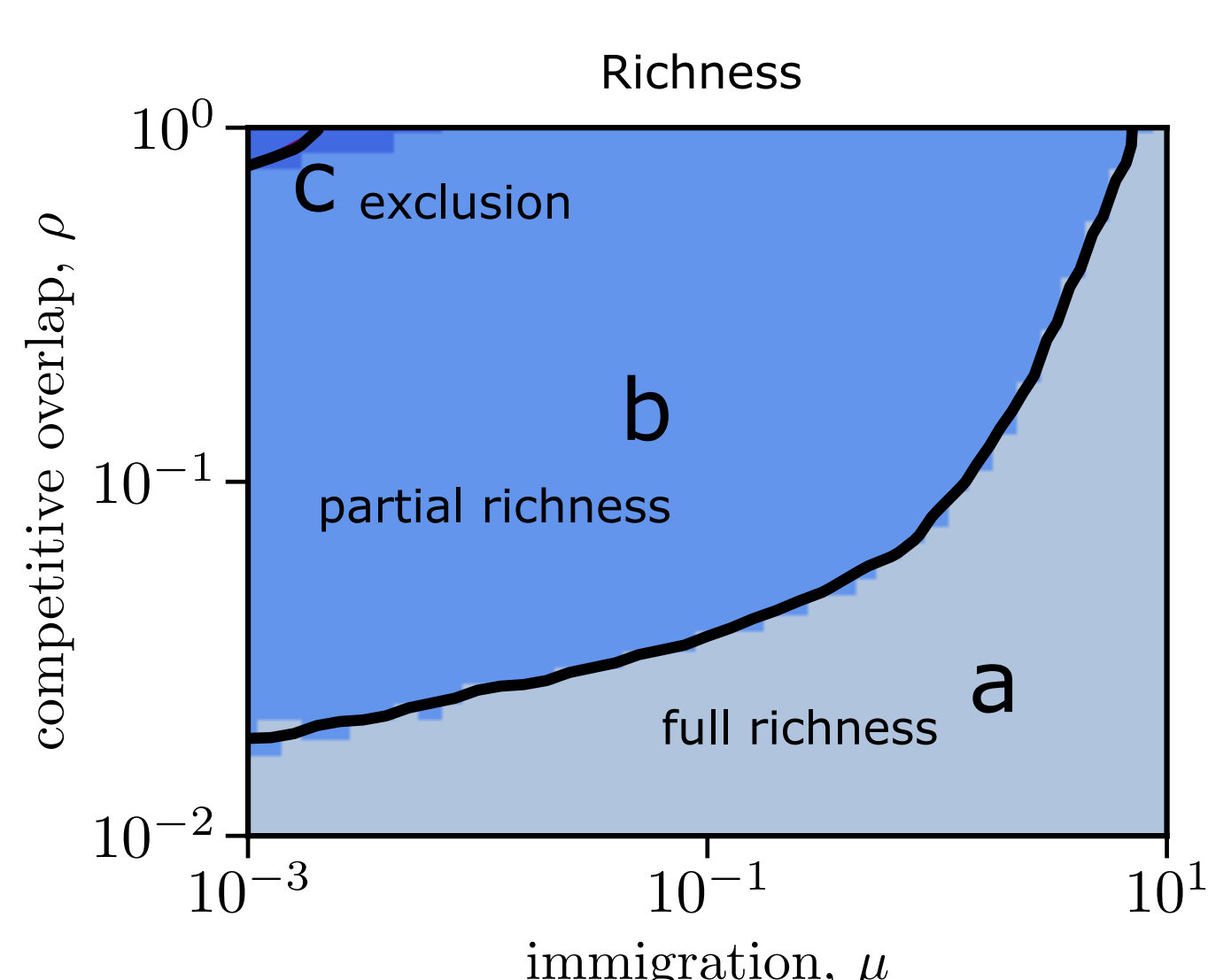
- unimodality
- bimodal (dominant-suppressed) =
- rare-biosphere
→ monotonously decreasing
- trimodality and beyond



RICHNESS

Richness = averaged # non-extinct species

- one existing species
- partial coexistence
- full coexisting



MATHEMATICAL FRAMEWORK

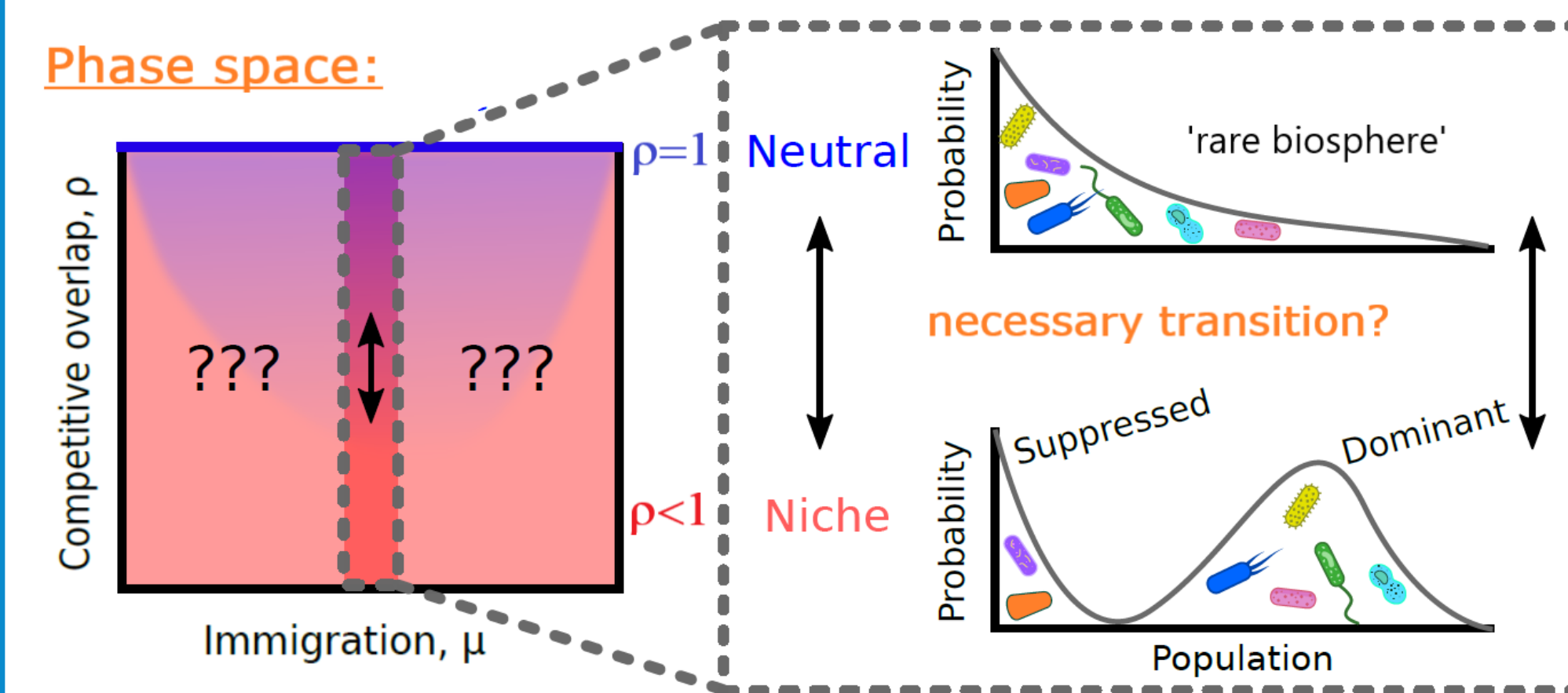
- Master equation with rates:

$$\begin{aligned} \text{birth } n_i \rightarrow n_i + 1 : & \quad r^+ n_i + \mu \\ \text{death } n_i \rightarrow n_i - 1 : & \quad r^- n_i + \frac{r^+ - r^-}{K} \left[n_i + \rho \sum_{j \neq i} n_j \right] \end{aligned} \quad (1)$$

n_i - # individuals of species i . $i \in \{1, \dots, S\}$ species index, $S = \#$ species. μ - immigration, K - carrying capacity, ρ - ratio between inter-specific and intra-specific competition.

- neutrality, $\rho = 1$: individuals similarly interact with all others, regardless of their species
- niche $\rho < 1$: individuals interact with their own kinds stronger than individual from other species
- species abundance distribution \iff marginal distribution of one species $P(n)$

MOTIVATION

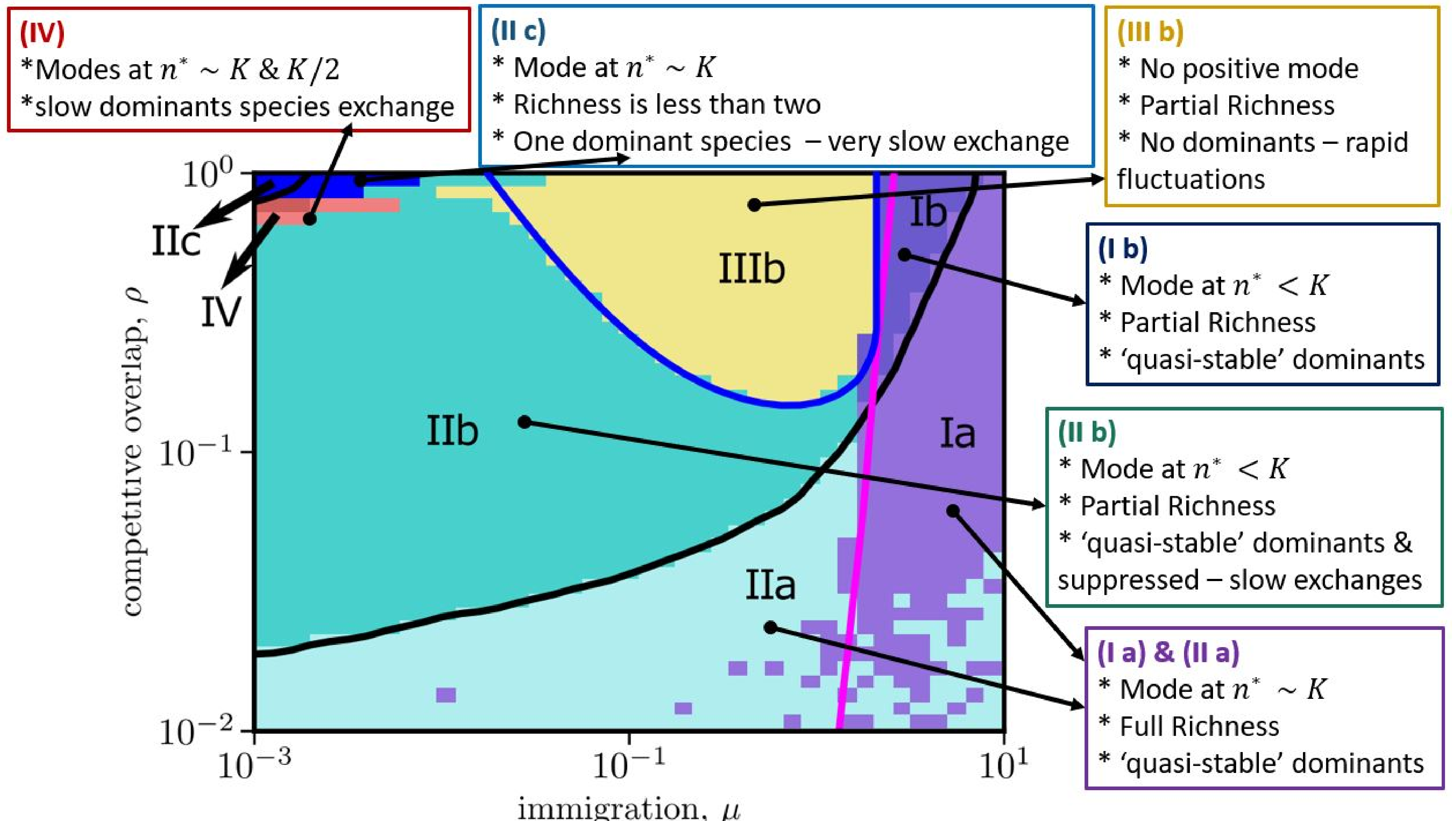


How does competition \leftrightarrow immigration affect the stationary behavior?

- Modality/richness/ stability?
- neutral \iff rare biosphere & niche \iff bimodality?
- classification beyond neutral/niche?

SUPERIMPOSED PHASE SPACE

Superposition of modality and richness phases gives rich behavior:



SUMMARY

- Presenting results from simulations (using Gillespie algorithm, represented by color-map) & analytic results derived using mean-field approach (solid lines).
- Obtaining various phases corresponding the behavior of the community
- Breaking common paradigm \implies neutral \neq rare-biosphere & bimodal \neq niche
- Extending dichotomous description beyond neutral-niche

See: N. Leibovich, J. Rothschild, A. Zilman, S. Goyal, (2022)
<https://arxiv.org/pdf/2205.02650.pdf>

? Further discussion and more questions? nava.leibovich@utoronto.ca