Effect of Hypocrite Population in Cyclic Dominance Models

Khademalghorani, Peyman; Azimi, Nahid

Department of physics, Institute for advanced studies in basic sciences

Institute for Advanced Studies in Basic Sciences
Gava Zang, Zanjan, Iran

INTRODUCTION

In social interactions, people are affected by each other's opinions. In the discussion, people may express an opinion based on their benefit that they do not believe in inwardly. We call these people *hypocrites*. We study the presence of hypocrites in a society in which people have three different opinion and compete according to the rock-paper-scissors (RPS) game. hypocrites interact with the possibility of α with outer opinion and $1 - \alpha$ with inner opinion. The schematic of the model is shown in Figure 1 .

Hypocrite	Outer opinion	Inner opinion	Symbol
R_P	Paper	Rock	M_1
S_R	Rock	Scissor	M_2
P_S	Scissor	Paper	M_3

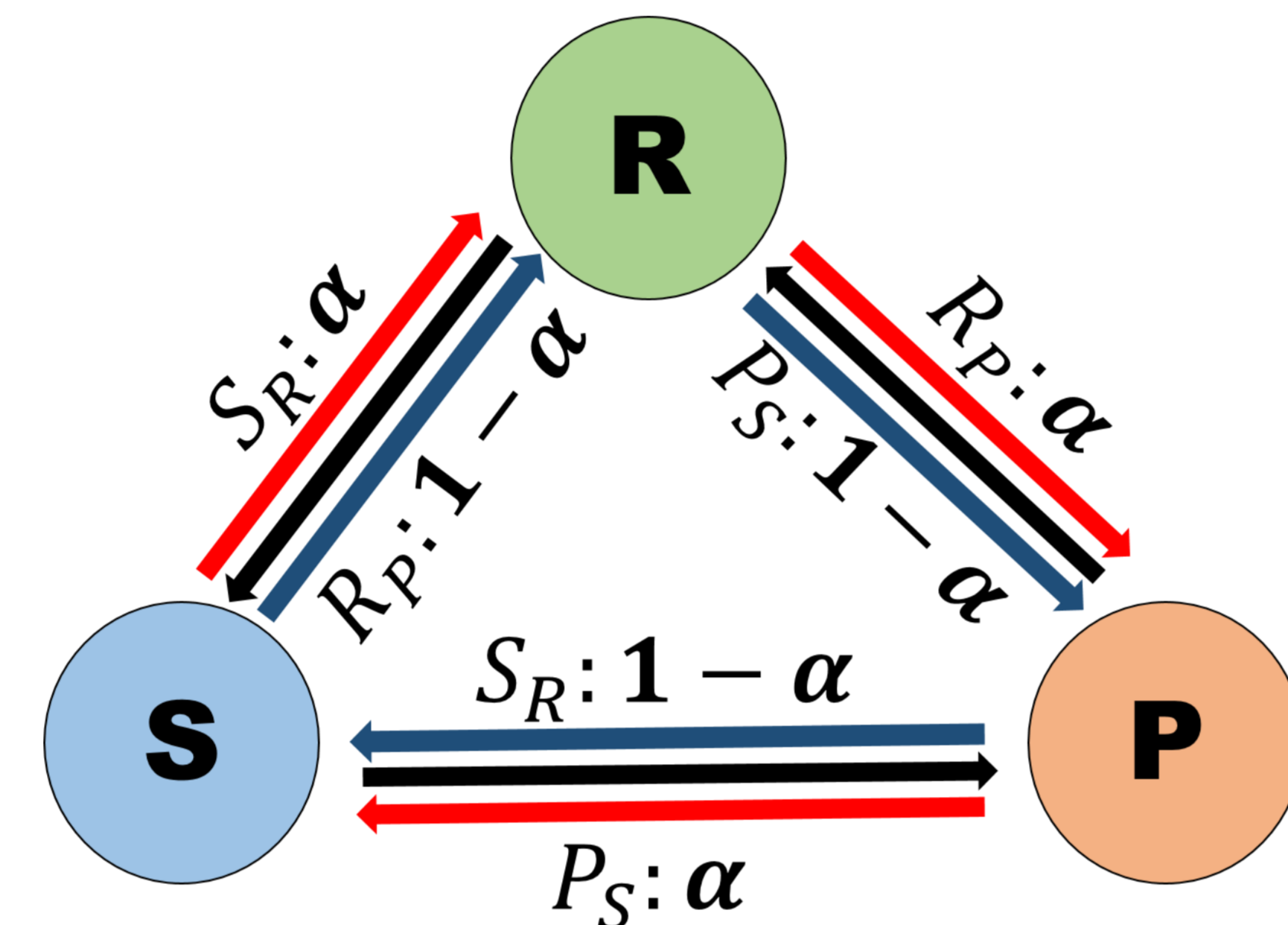*Table 1: introduce hypocrite population*

Fig1: Scheme of RPS model interactions with hypocrite

Mean-field equations

$$\frac{dR}{dt} = \mathrm{RS} + (1-\alpha)M_1\mathrm{S} + \alpha M_2\mathrm{S} - \mathrm{RP} - \alpha M_1 \mathrm{R} - (1-\alpha)M_3 R$$

$$\frac{dP}{dt} = RP + \alpha M_1 R + (1-\alpha)M_3 R - SP - (1-\alpha)M_2 P - \alpha M_3 P$$

$$\frac{dS}{dt} = SP + (1-\alpha)M_2 P + \alpha M_3 P - RS - (1-\alpha)M_1 S - \alpha M_2 S$$

RPS in presence of R_P

- $\{P^* = 1 - M, \ R^* = S^* = 0\}$ P-survive

- $\begin{cases} R^* = 0.66(1 + (-5 + 3\alpha)M + \sqrt{1 + M(2 + M - 3\alpha(2 - 2\alpha M))}) \\ P^* = 0.66\left(1 + M - 3\alpha M + \sqrt{1 + M - 6\alpha^2 M}\right) \\ S^* = 0.33(2 - M - \sqrt{1 + M(2 + M - 3\alpha(2 - 2\alpha M))}) \end{cases}$ Coexistence
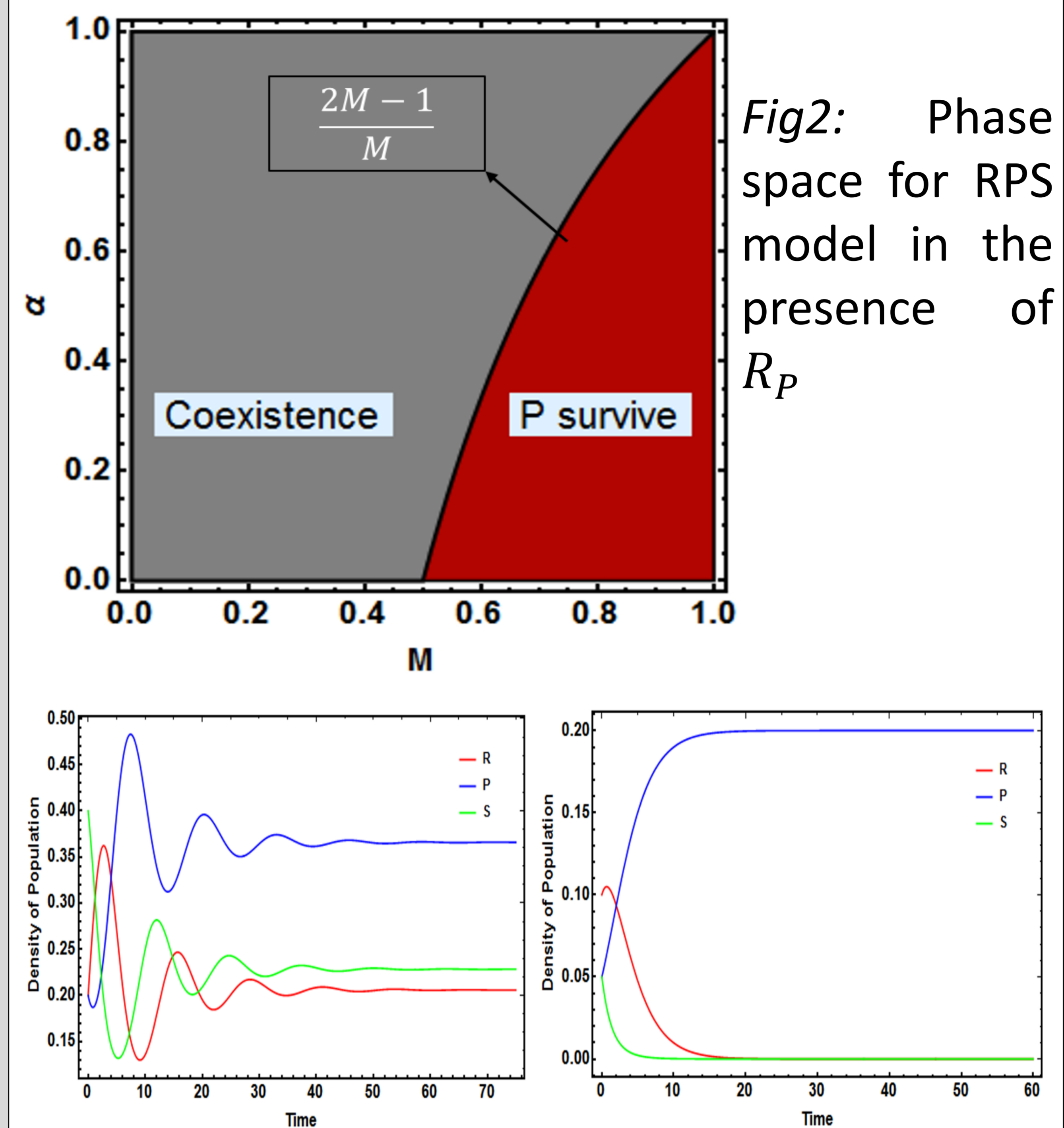

Fig2: Phase space for RPS model in the presence of R_P

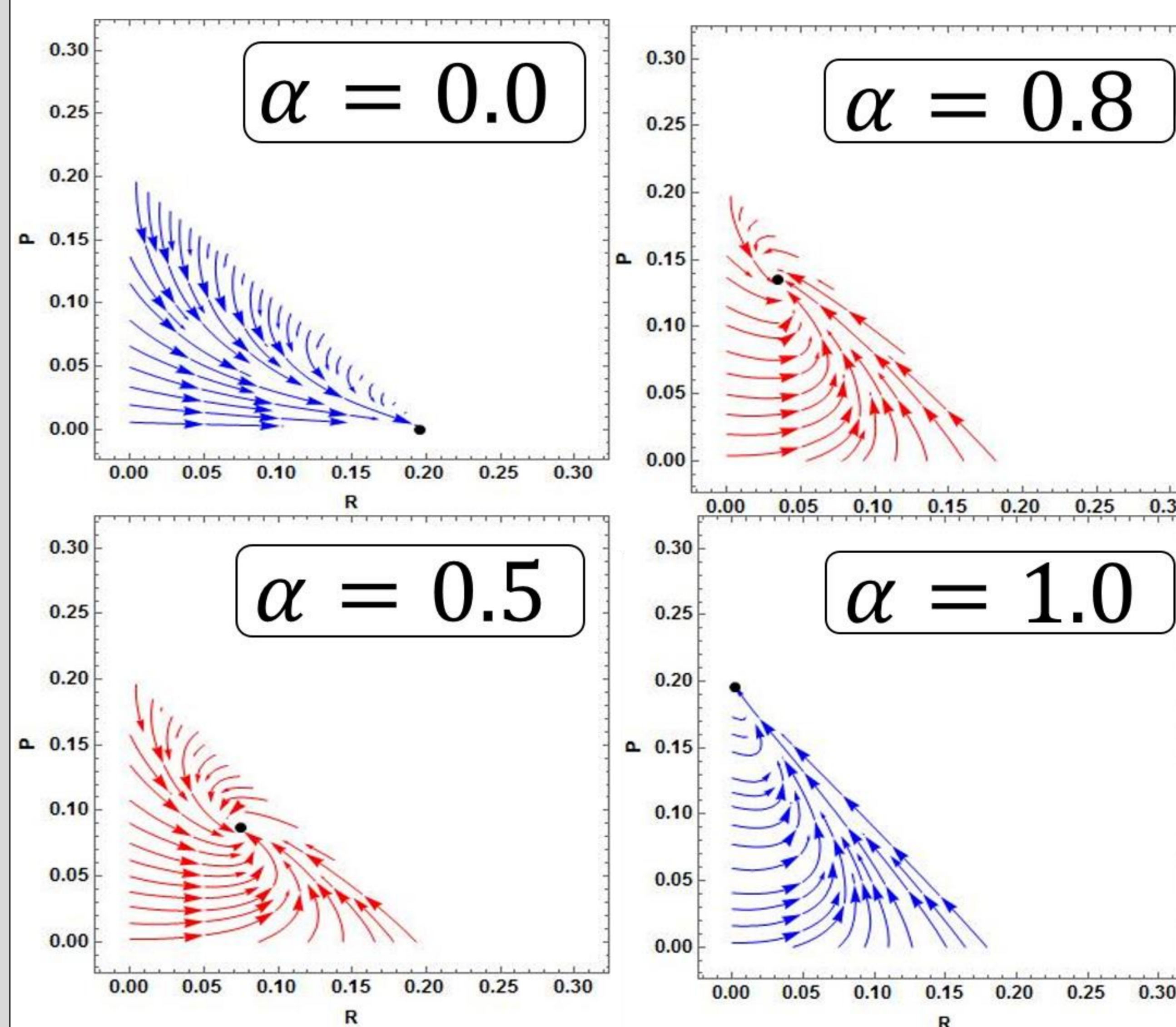## RPS in presence of R_P, S_R

$$M_1 = M_2 = M$$

Fig3: Phase space for RPS model in the presence of two group hypocrite for M = 0.4.
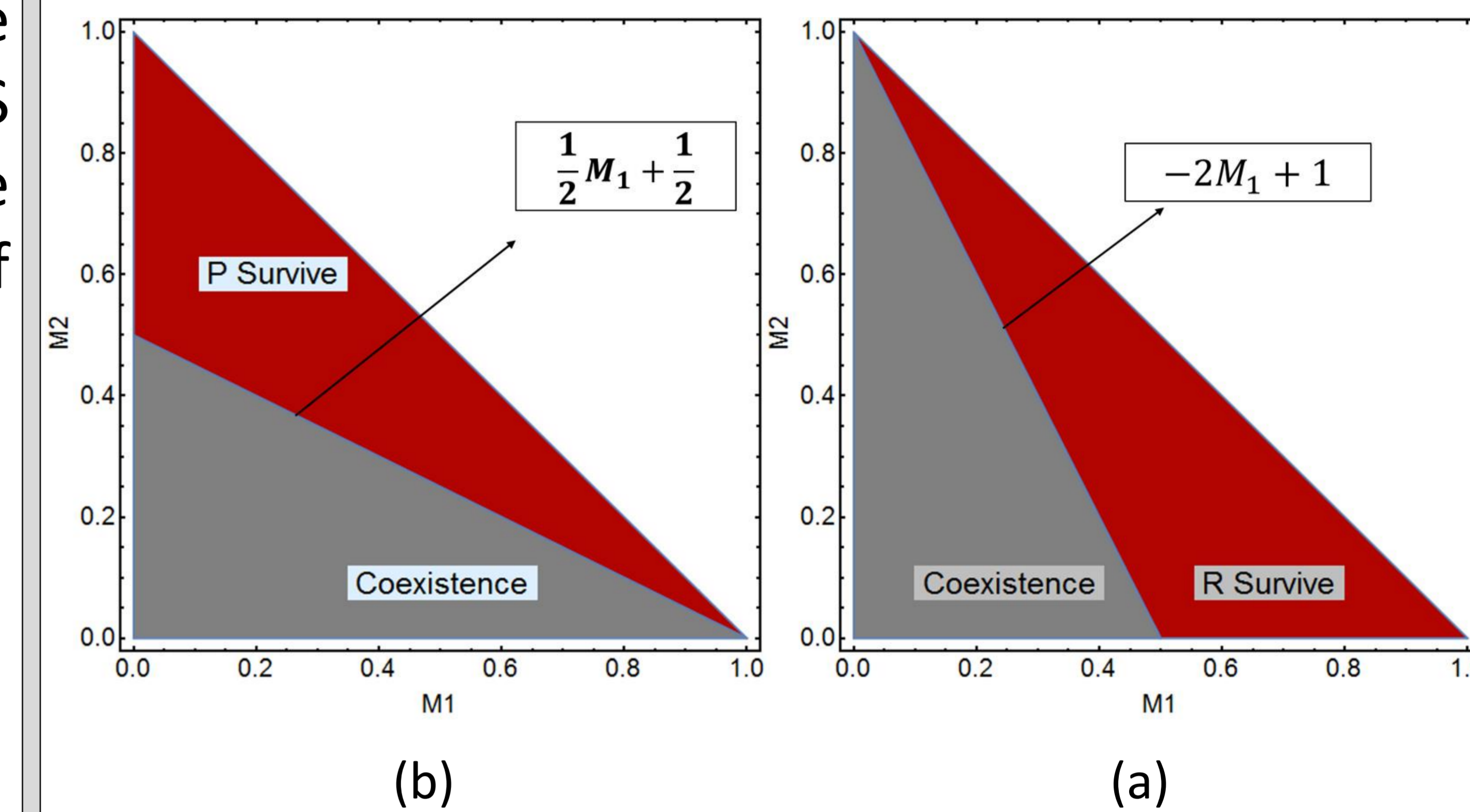
$M_1 \neq M_2$

Fig4: Phase space in the presence of two groups of hypocrite (a) $\alpha = 0$ and (b) $\alpha = 1$

RPS in presence of R_P, S_R, P_S

$$M_1 = M_2 = M_3 = M$$

- $\{R^* = P^* = S^* = \frac{1}{3}(1 - 3M)\}$

In this case, system is always in the coexistence phase.

Conclusion

The density of hypocrites and also the amount of hypocrisy of these people can lead to a coexistence phase or cause one or two kinds of opinions to disappear and eventually a consensus on a opinion to occur.

References

[1] Castellano, *Reviews of modern physics* 81.2 (2009): 591
[2] Gastner, Michael T., et al *PloS one* 14.6 (2019): e0218729