Enzyme rhythms in model linear_chain_dilution.speedy - spontaneous oscillations

Model name: linear_chain_dilution

o Optimisation problem
- Protein turnover time 1 s = 0.0167 min
- Perturbed parameter(s) : x1
- Perturbation frequency f : 0.1/s (period 10 s)
- Scored quantity: v4
- State-averaged fitness
- No posttranslational rhythms allowed
- Standard frequency considered f : 0.1/s (period 10 s)

o Model properties:
- inactive_enzymes: 0
- balanced_reference_state: 1
- consider_external_rhythm: 1
- adaptive_rhythm: 0
- spontaneous_rhythm: 1
- spontaneous_rhythm_at_omega: 1
- has_spontaneous_rhythm_and_inactive_enzymes: 0

o Beneficial autonomous oscillation found
- Maximum principal synergy found (in tested range) at frequency f =0.01/s (period 100 s)
- Maximum fitness found (in tested range) at frequency f =0.01/s (period 100 s)

o Fitness changes after external perturbation at frequency f=0.1/s
- Change by perturbation alone (xx): -2.12e-13

o Autonomous oscillations?
- Maximally autonomous oscillations (in tested range) at f = 0.01, principal synergy 0.0014
- Beneficial autonomous oscillations found at frequency f = 0.1/s (principal synergy = 0.00132)
- Predicted fitness change (autonomous, 2nd order, amplitude below 1/2 of mean) at frequency f =0.1: 0.0854
- Predicted maximal fitness change (autonomous, numeric opt, full amplitude constraints) at frequency f =0.01: 0.914
WARNING: an external rhythm is given and an autonomous rhythm has been found

o Numerical calculation (responsive, f=0.1)
- Fitness change (fitness-averaged): -0.000216
- Fitness change (state-averaged): -0.000205

o Numerical calculation (autonomous rhythm, amplitude below 1/2 of mean, f=0.1)
- Fitness change (fitness-averaged) : -1.7
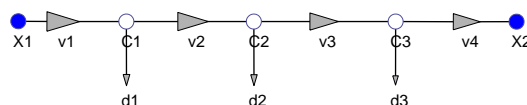- Fitness change (state-averaged): -0.0296
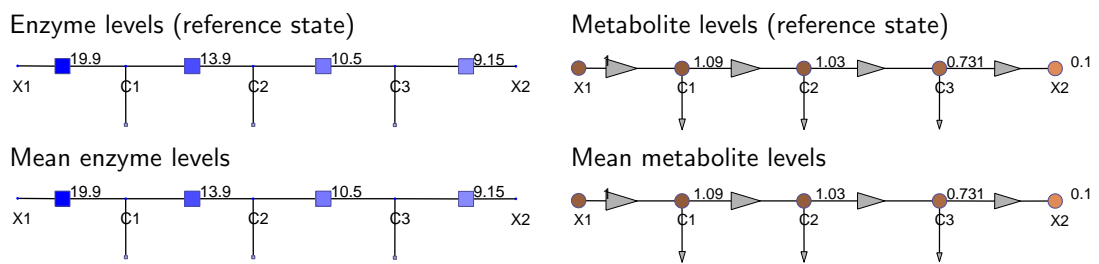

Figure 1: Network and reference flux

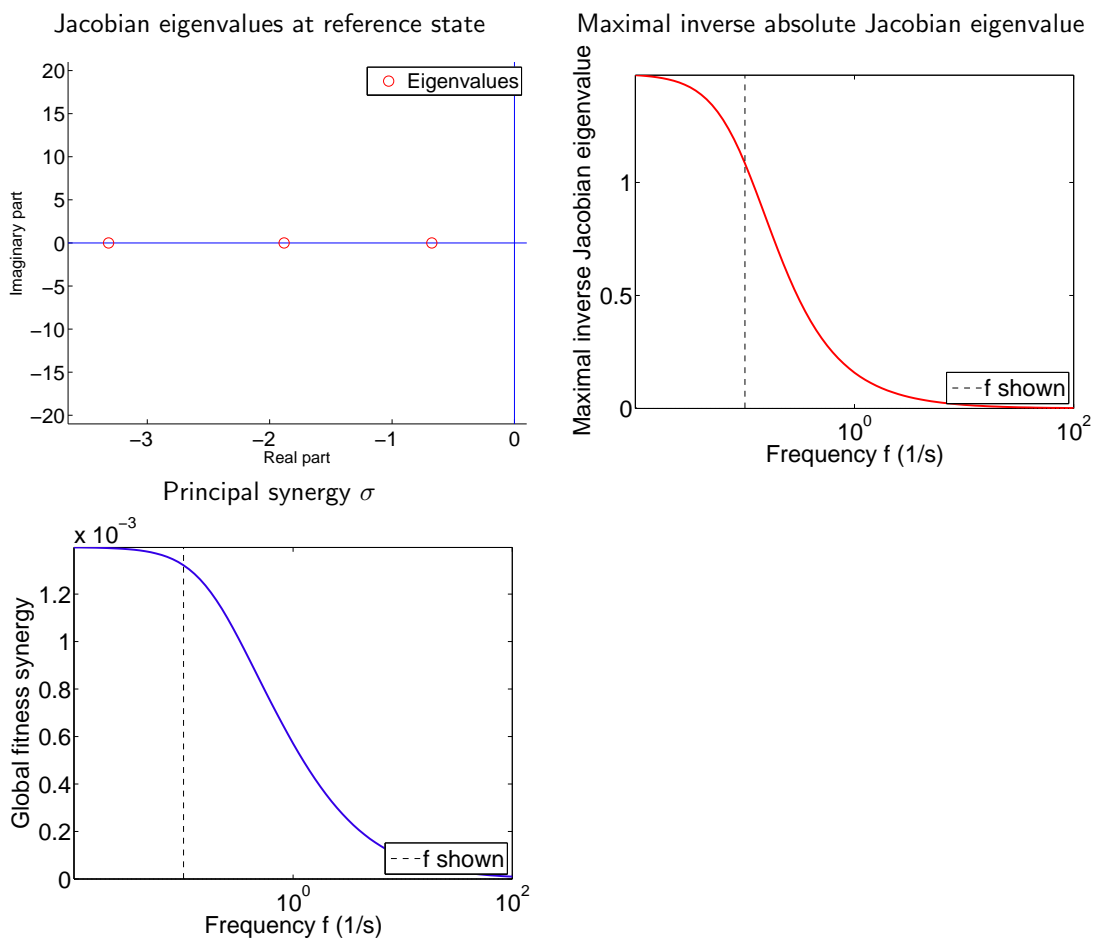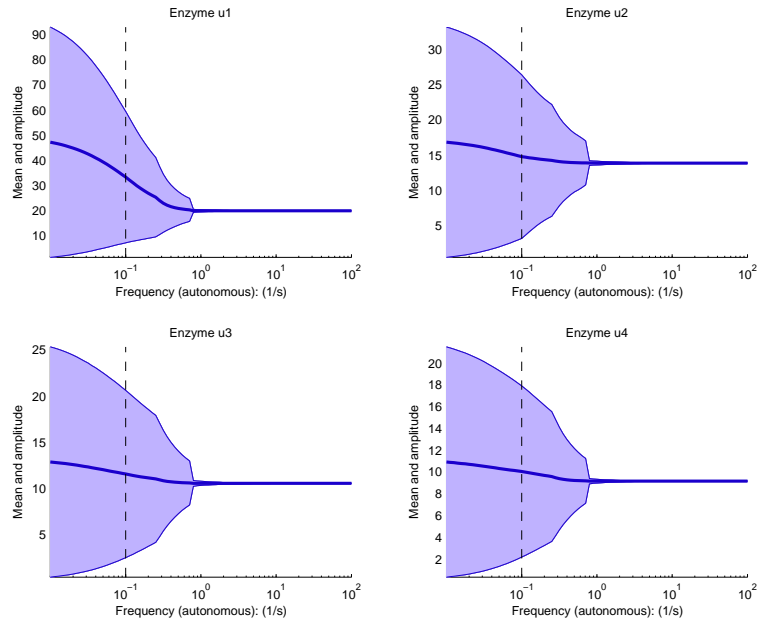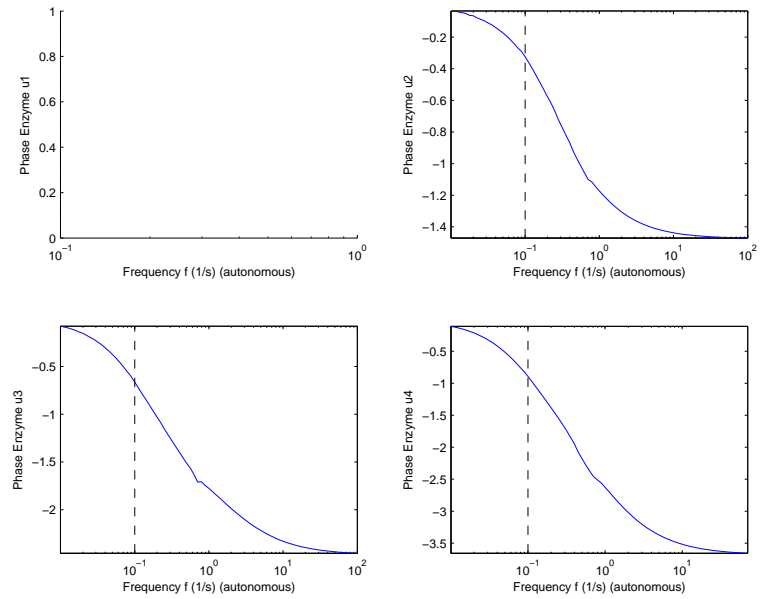Figure 2: Reference state (top) and mean state during oscillation (bottom).

Figure 3: Control analysis: fitness curvatures. Left: Frequency-dependent fitness curvature eigenvalues. Right: relative sizes and phases of the individual enzyme levels (components of the leading fitness curvature eigenvector).
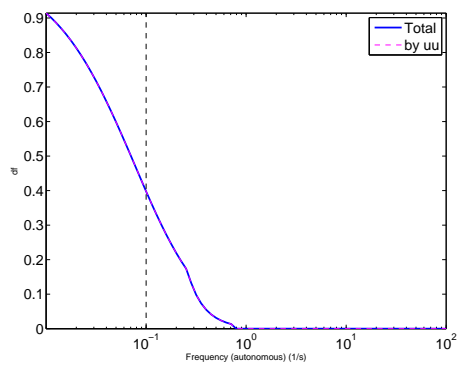
Figure 4: Self-promoting oscillations. Left: amplitudes of protein levels (blue) and modification (grey). Right: phase shifts.
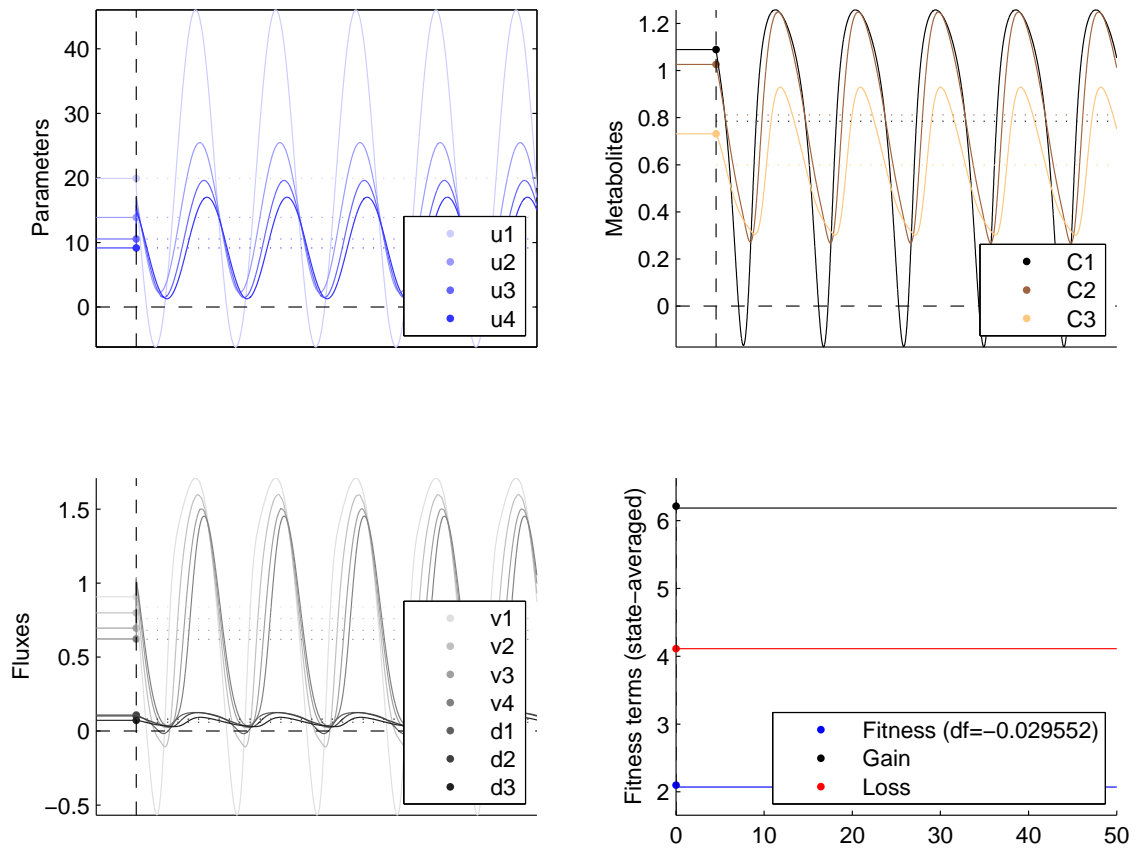
Figure 5: Numerical calculations: spontaneous oscillations. Perturbation frequency see first page.
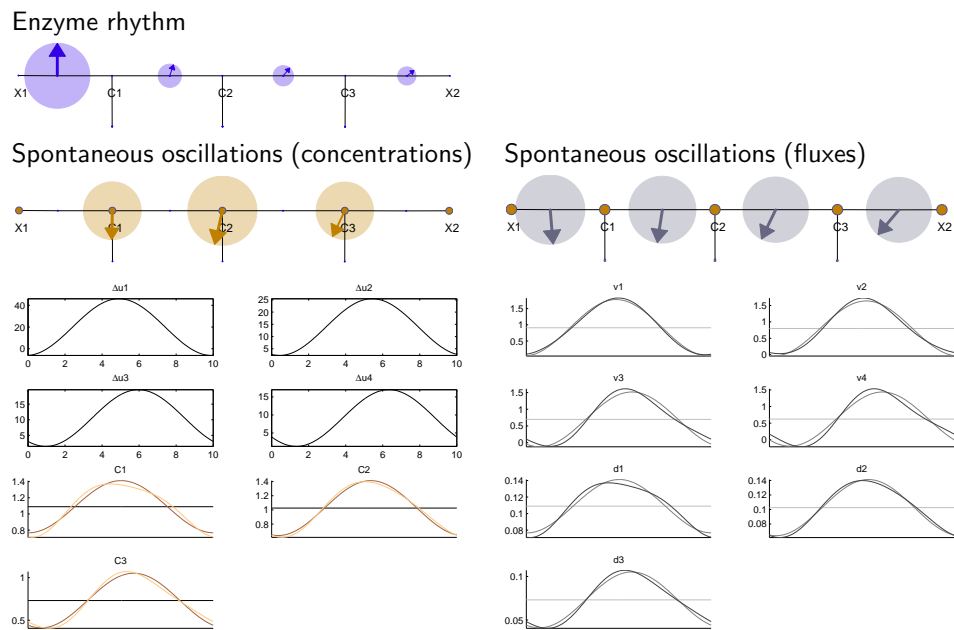

Figure 6: Spontaneous oscillations (local expansion; arrows: absolute changes). Perturbation frequency see first page.
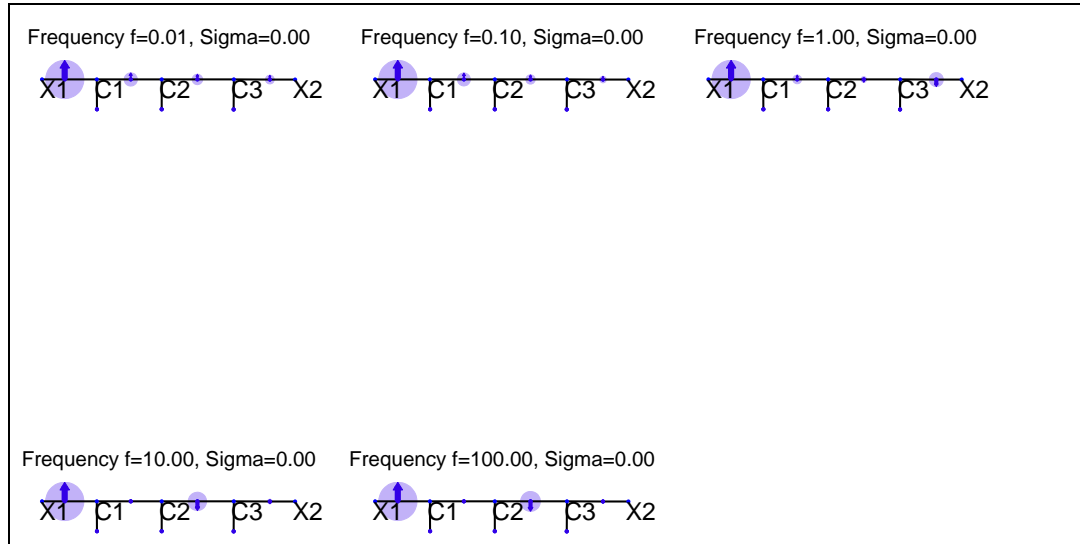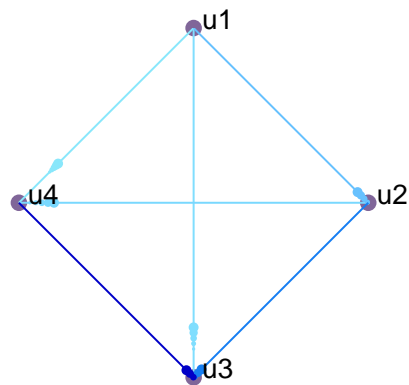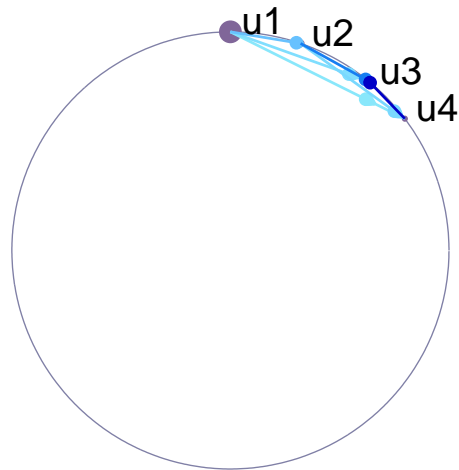
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Spontaneous oscillations

Figure 7: Spontaneous oscillations (or tendencies towards them) for various circular frequencies ω. If the maximal fitness curvatures λ is positive, the rhythm is beneficial (local expansion; arrows: absolute changes).
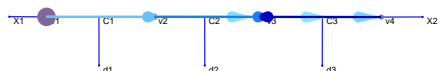

Figure 8: Periodic economic potentials and direct enzyme values.