Dynamics of a ring network with a linear tail

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This paper considers the interactions between a coupled ring and linear tail of directionally coupled Stuart-Landau oscillators. The linear tail is driven by the ring, and the system can be described by the following differential equation

$$\dot{x}_j(t) = (\alpha + \mathrm{i}\beta)x_j(t) + x_{j-1}(t) - x_j(t)|x_j(t)|^2\,,$$

where $j = 1, 2, \ldots, m+n$, $\alpha, \beta \in \mathbb{R}$, $\mathrm{i}^2 = -1$, $x_j(t)$ is the complex variable.

We fist investigate the stability of the trivial equilibrium of the system using the characteristic roots method, and give the conditions that the ring network generates the stable rotating waves. And then a detailed theoretical analysis that the rotating waves generating from the ring can propagate along the linear tail is presented. The two nodes in the linear tails have the same oscillations if the number of the nodes between them is a multiple of the nodes number in the ring. We also discuss the effects of the disturbance in the ring and linear tail on the synchronization, and investigate the synchronized time. During the propagation of the rotating wave, the disturbance will accumulate and the time of node synchronization grow longer for a large number of the node in the linear tail. Numerically it is shown that the stabilities of the synchronized states are degraded when the oscillators in the linear tails are far from the ring.

Keywords: synchronization; rotating waves; stability; bifurcation; complex network

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