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QUALITATIVE ANALYSIS OF A MODEL OF THE CELL DIVISION CYCLE

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Abstract. This paper qualitatively analyzes the mathematical model of the cell division for the interactions of Cdc2 and cyclin constructed by Tyson. Some basic dynamical properties such as existence and stability of its steady state, and bifurcations are investigated. Especially, the existence of limit cycle is proved. These conclusions concur well with Tyson's numerical results.

Keywords. Cell division, bifurcation, periodic solution, existence
AMS (MOS) subject classification:

1 Introduction

With the soaring development of biology sciences, cell signal transduction, cell apoptosis, genome and post-genomic analysis attract the attention of more and more people [3, 8]. The cell division cycle is the sequence of events by which a growing cell duplicates all its components and then divides this material between two daughter cells so that they can repeat the process [1, 6, 7]. The proteins Cdc2 and cyclin (their meaning are referred in [1, 5]) form a heterodimer (maturation promoting factor) that controls the major events of the cell cycle.

Tyson studied the cyclin-Cdc2 cycle by using network and kinetic equations [8]. Firstly synthesized cyclin subunits combine with preexisting Cdc2 subunits to form an inactive MPF complex. Secondly the complex is activated, in an autocatalytic fashion, by dephosphorylation at a specific tyrosine residue of the Cdc2 subunit. Then active MPF is known to estimate the MPF complex dissociates, and the cyclin subunit is rapidly degraded. Finally the cycle repeats itself. Tyson model for the interactions of Cdc2 and cyclin is:

$$\begin{aligned}
\tfrac{d[C2]}{dt} &= k_6[M] - k_8[\,P][C2] + k_9[CP]\,,\\
\tfrac{d[CP]}{dt} &= -k_3[CP][Y] + k_8[\,P][C2] - k_9[CP]\,,\\
\tfrac{d[pM]}{dt} &= k_3[CP][Y] - [pM]F([M]) + k_5[\,P][M]\,,\\
\tfrac{d[M]}{dt} &= [pM]F([M]) - k_5[\,P][M] - k_6[M]\,,\\
\tfrac{d[Y]}{dt} &= k_1[aa] - k_2[Y] - k_3[CP][Y]\,,\\
\tfrac{d[YP]}{dt} &= k_6[M] - k_7[YP]\,,
\end{aligned}$$