The detailed model consists of 180 variables and 70 parameters.

### **Step 1: Fixing Variables**

We fixed the output variable (Output (21) = MnB\_dot) and analyzed the bifurcation types associated with individual parameters and various parameter sets. To simulate the effects of temperature changes, the factorlist value was reduced from 1 (high temperature) to 0 (low temperature), representing proportional changes in parameter values corresponding to decreasing temperatures.

### **Simulation 1: Single-Parameter Analysis (Figure 4A)**

1. **Transcription Rate for Bmal1 (trB)**
   * **Parameter**: parameterValueNew(5)
   * **Observations**: As the factorlist value decreased, the amplitude of oscillations gradually reduced to zero, while the period remained relatively constant.
   * **Conclusion**: These results indicate the occurrence of **Hopf bifurcation** for the transcription rate of Bmal1.
2. **Transcription Rate for Per1 (trPo)**
   * **Parameter**: parameterValueNew(1)
   * **Observations**: Both the amplitude and period remained relatively constant as the factorlist value decreased.
   * **Conclusion**: These results indicate that **no bifurcation** occurs for the transcription rate of Per1.

### **Simulation 2: Multiple-Parameter Analysis (Figure 4A)**

Three parameters were analyzed simultaneously to determine their combined impact:

1. **Parameter No. 63**: Degradation rate of Bmal1.
2. **Parameter No. 30**: Unbinding rate of Rev-erb from NPAS2.
3. **Parameter No. 19**: Unbinding rate of PER from CRY.
   * **Observations**: As the factorlist value decreased, the period of oscillations gradually approached infinity, while the amplitude remained relatively constant.
   * **Conclusion**: These results indicate the occurrence of **SNIC bifurcation** for this specific parameter set.

The interactions among these parameters were analyzed, providing insights into their contributions to the bifurcation dynamics of the circadian system.

### **Categorizing Bifurcations**

By systematically analyzing the probabilities of Hopf and SNIC bifurcations:

* **Hopf bifurcation**: The probability was positively correlated with the number of parameters.
* **SNIC bifurcation**: The likelihood of SNIC bifurcation exist small occurence.

These findings suggest that **Hopf bifurcation** is the predominant mechanism in the detailed model (Figure 4B).