Effect of observation time in data assimilation by means of synchronization (Chua oscillator)

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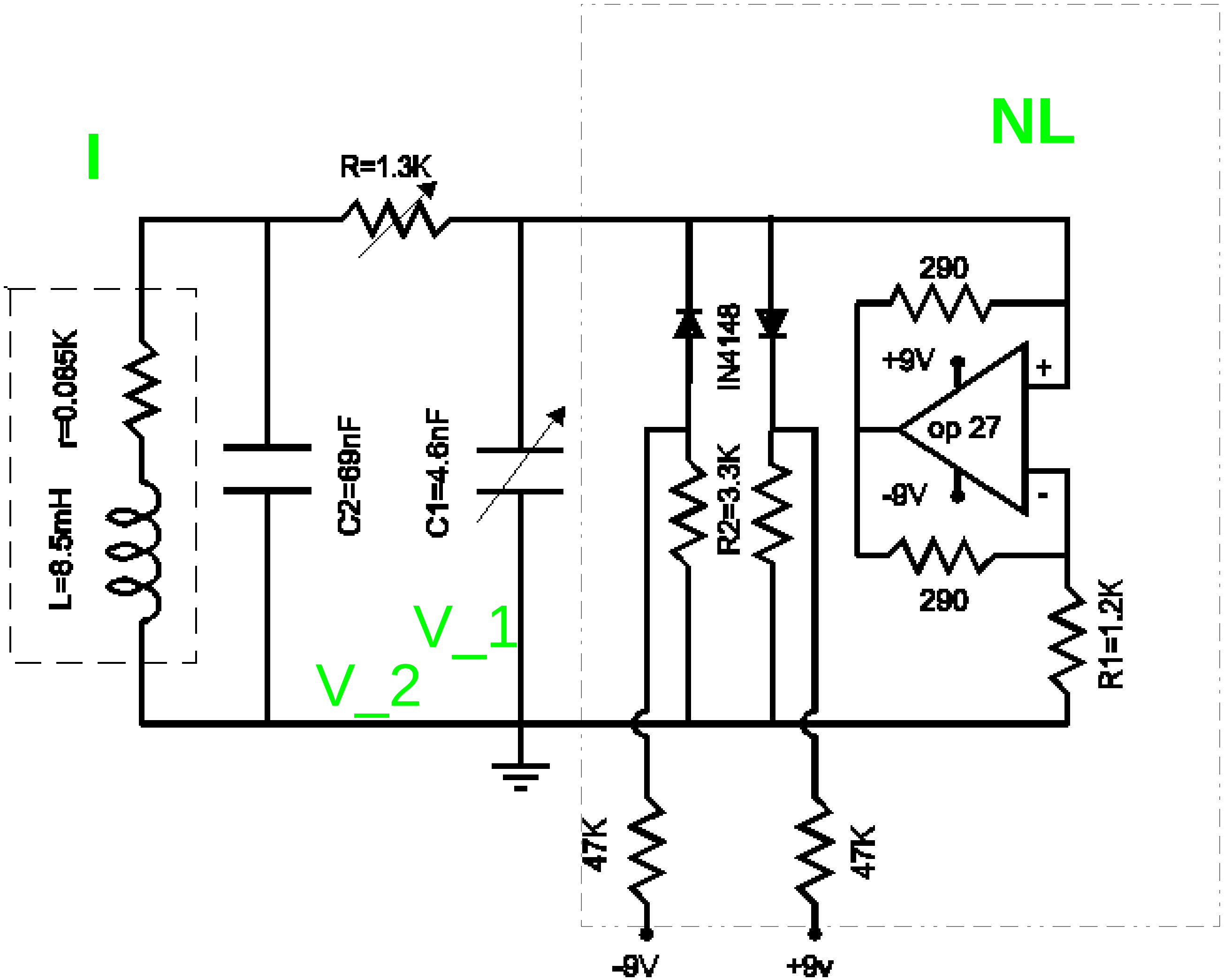
Ref: *S.C. Yang et al, Data Assimilation as Synchronization of Truth and Model: Experiments with the Three-Variable Lorenz System,* ***J. Atmospheric Sciences 63,*** *2340 (2006).*

Outline

1. **Chua model**
2. **Master-slave synchronization**
3. **Results**
4. **Conclusion**



I
NL
R=1.3K
r=0.065K
L=8.5mH
C2=69nF
C1=4.6nF
V_1
V_2
IN4148
R2=3.3K
290
290
+9V
-9V
op 27
+
-
R1=1.2K
47K
47K
-9V
+9v

Non-dimentional model Chua CKT

$$\frac{dX}{dt} = \frac{1200}{R}(Y - X) - g(X)$$

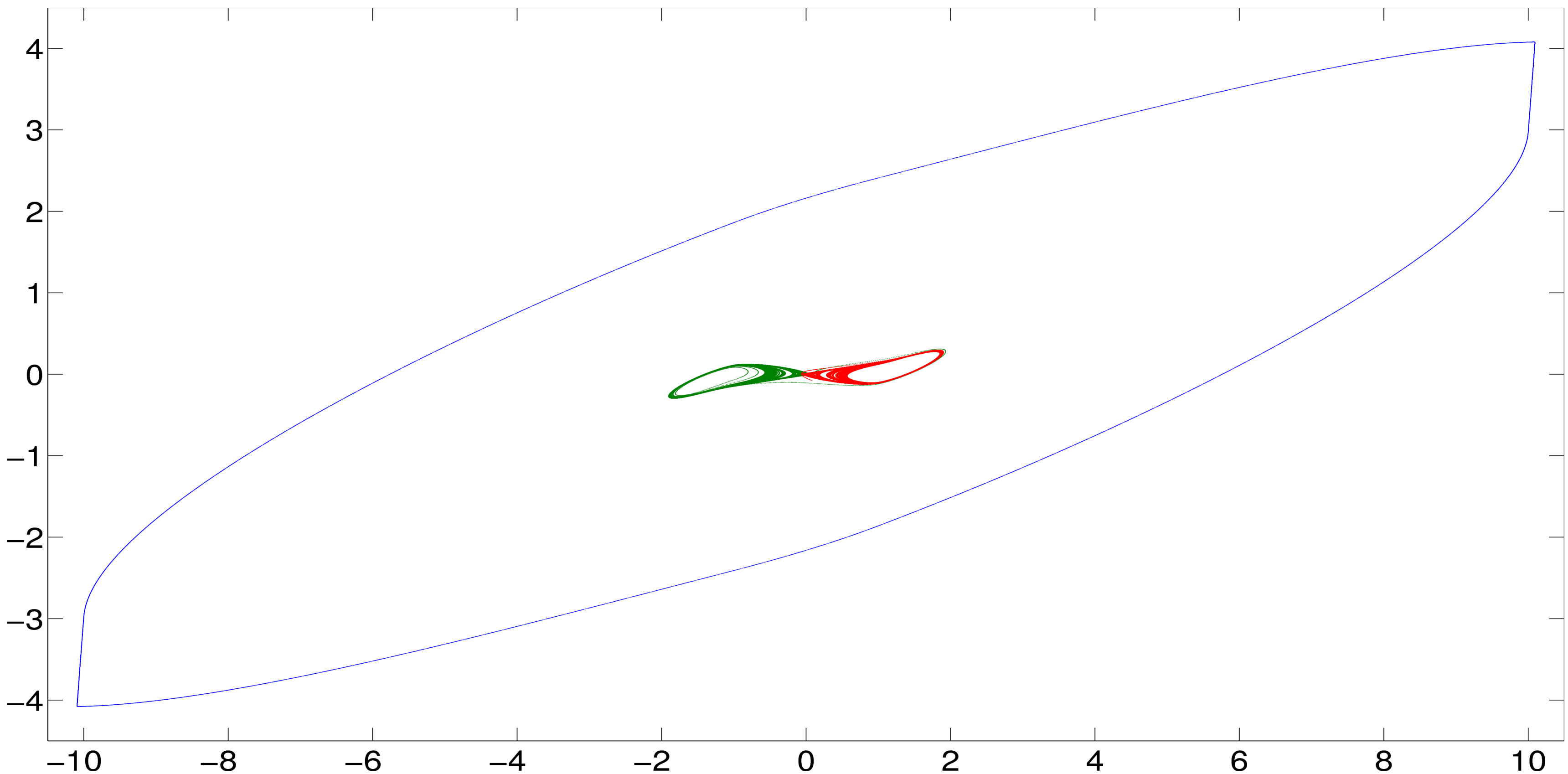
$$\frac{dY}{dt} = \sigma\left[\frac{-1200}{R}(Y - X) + Z\right]$$

$$\frac{dZ}{dt} = -c\left[Y + r' Z\right]$$

R is taken as a control parameter and the non-linear function **g(X)** is given by:

$$g(X) = \begin{cases} X, & |X| < 1 \\ -[1 + b(|X| - 1)]\, sign(X), & 1 < |X| \leqslant 10 \\ 10[(|X| - 10) - (9b + 1)]\, sign(X), & 10 < |X| \end{cases}$$

$$\sigma = \frac{C_1}{C_2}, \quad c = \frac{C_1 R_1^2}{L}, \quad r' = \frac{r}{R_1}, \quad b = 1 - \frac{R_1}{R_2}$$



4
3
2
1
0
−1
−2
−3
−4
−10
−8
−6
−4
−2
0
2
4
6
8
10

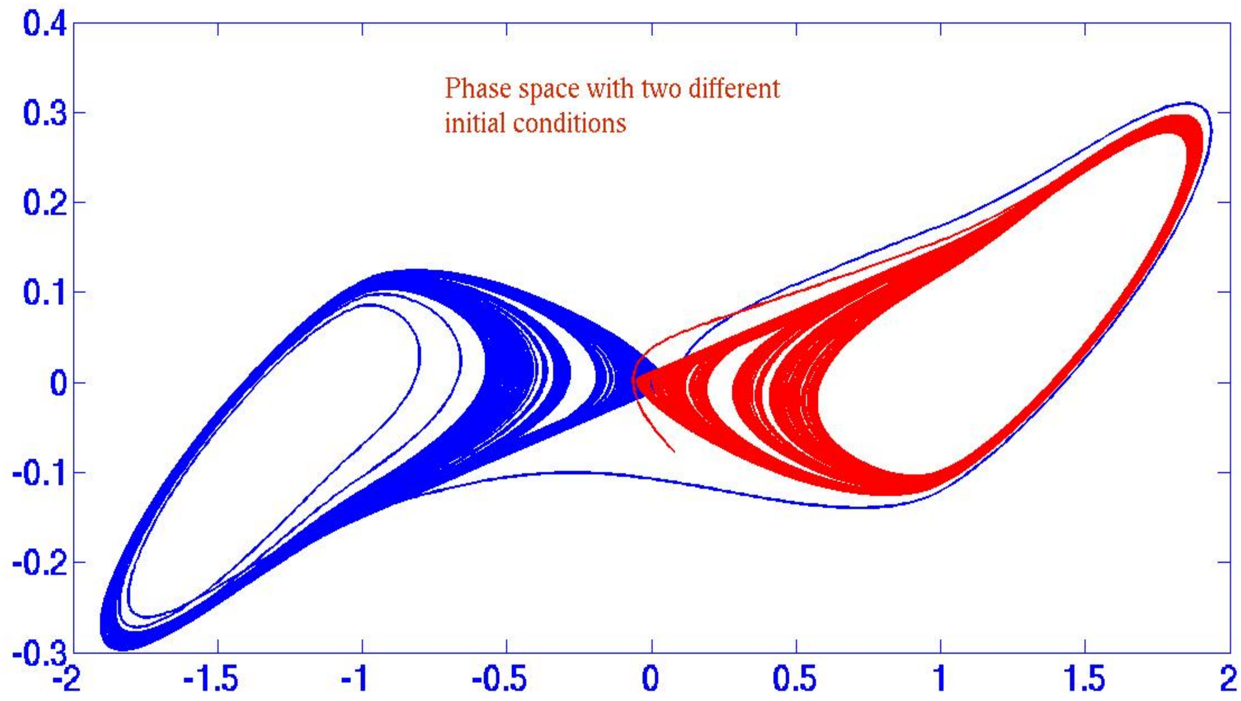


Fig1. X-Y plot with two different Initial conditions.

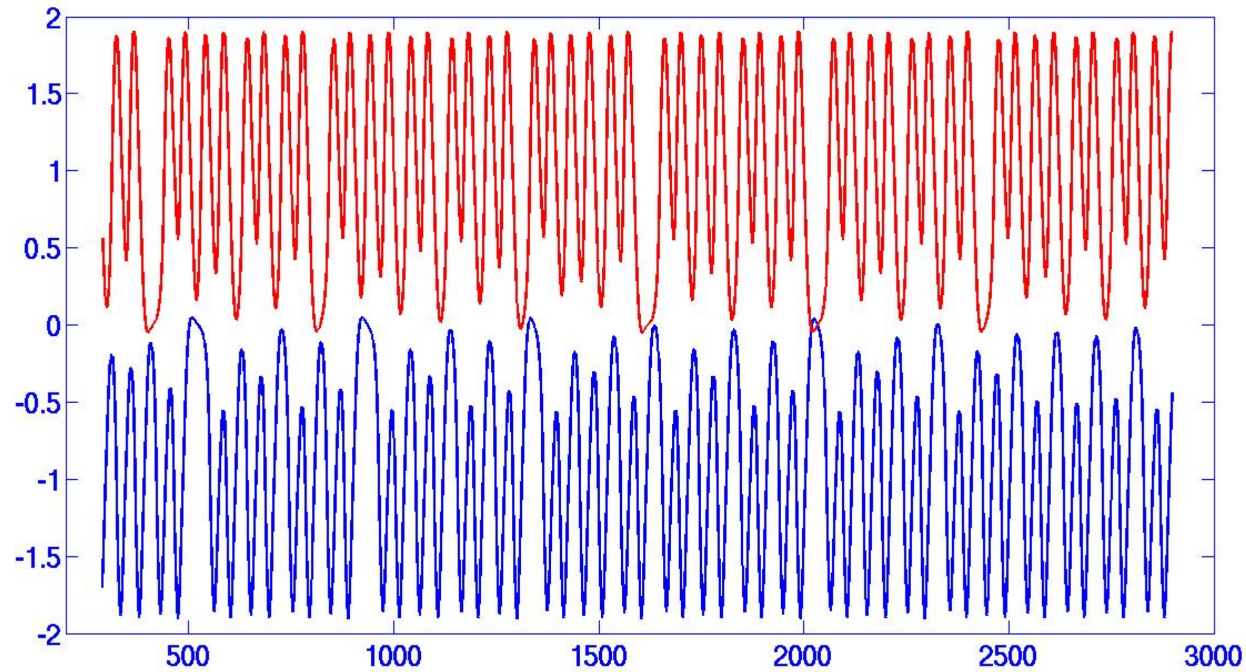
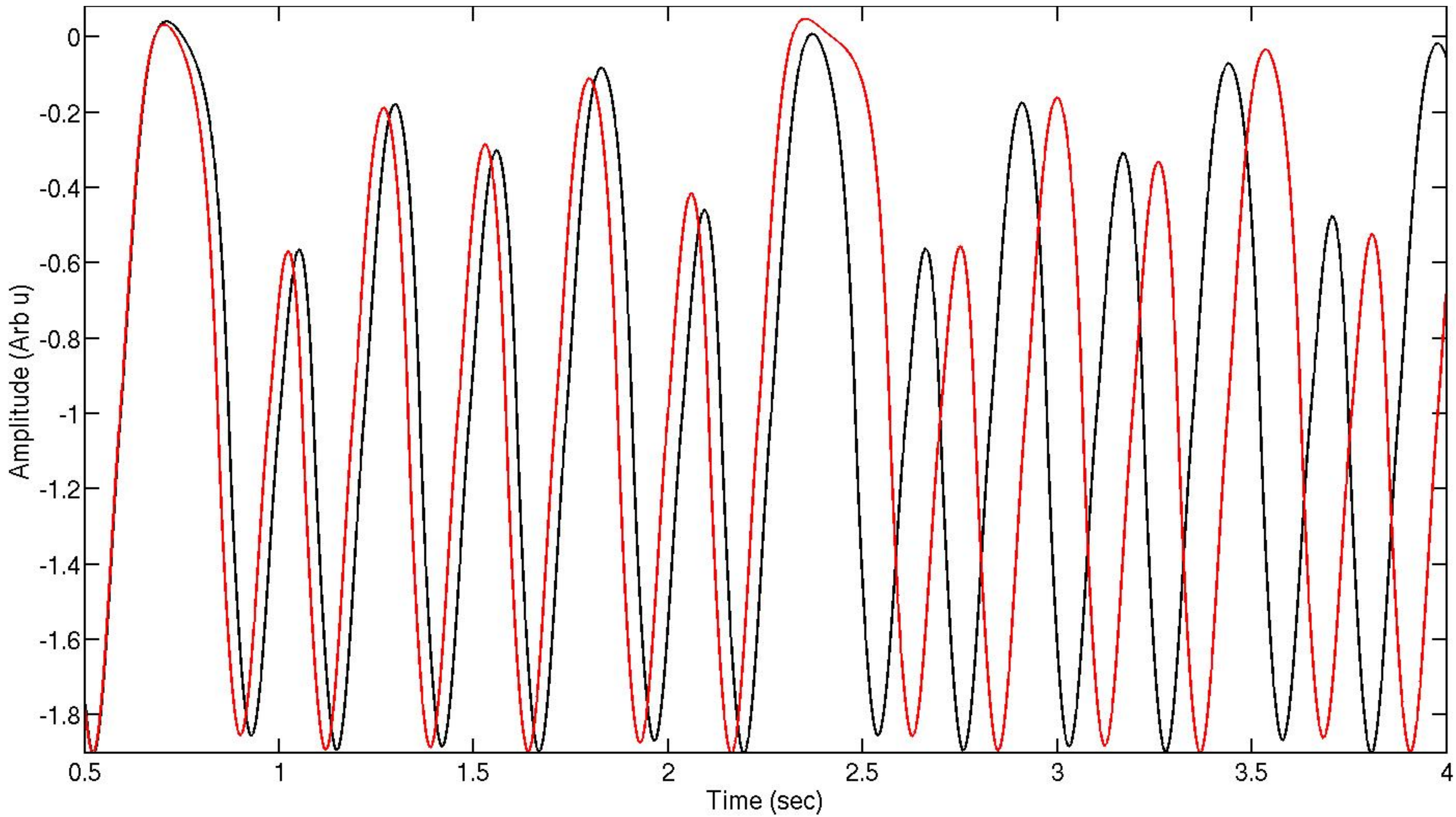


Fig2. X variable for above two cases.



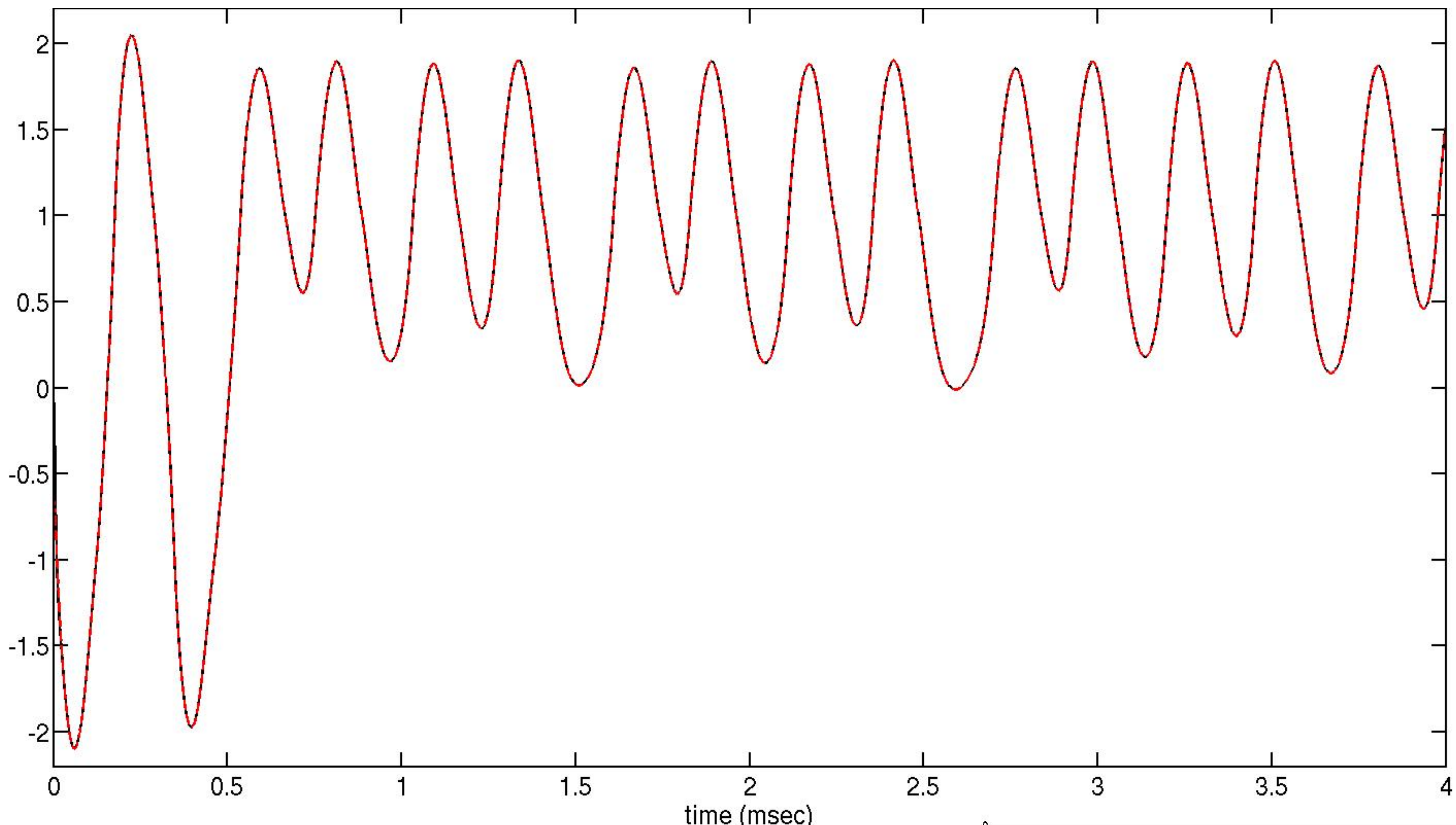
Λ=4/ msec, t=1/Λ=2.5X10^{-4}

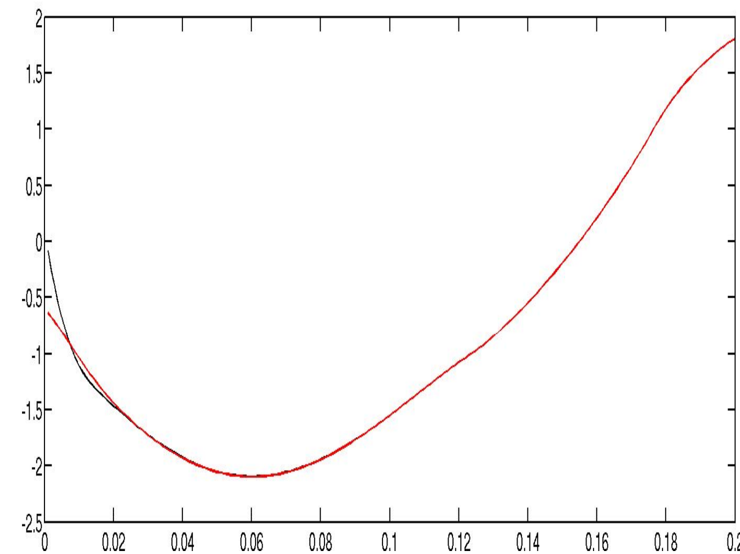
$$\frac{dX}{d\tau} = \frac{1200}{R}(Y - X) - g(X) - k(1) * (X_s - X_{obs})$$

$$\frac{dY}{d\tau} = \sigma[\frac{1200}{R}(Y - X) + Z] - k(2) * (Y_s - Y_{obs})$$

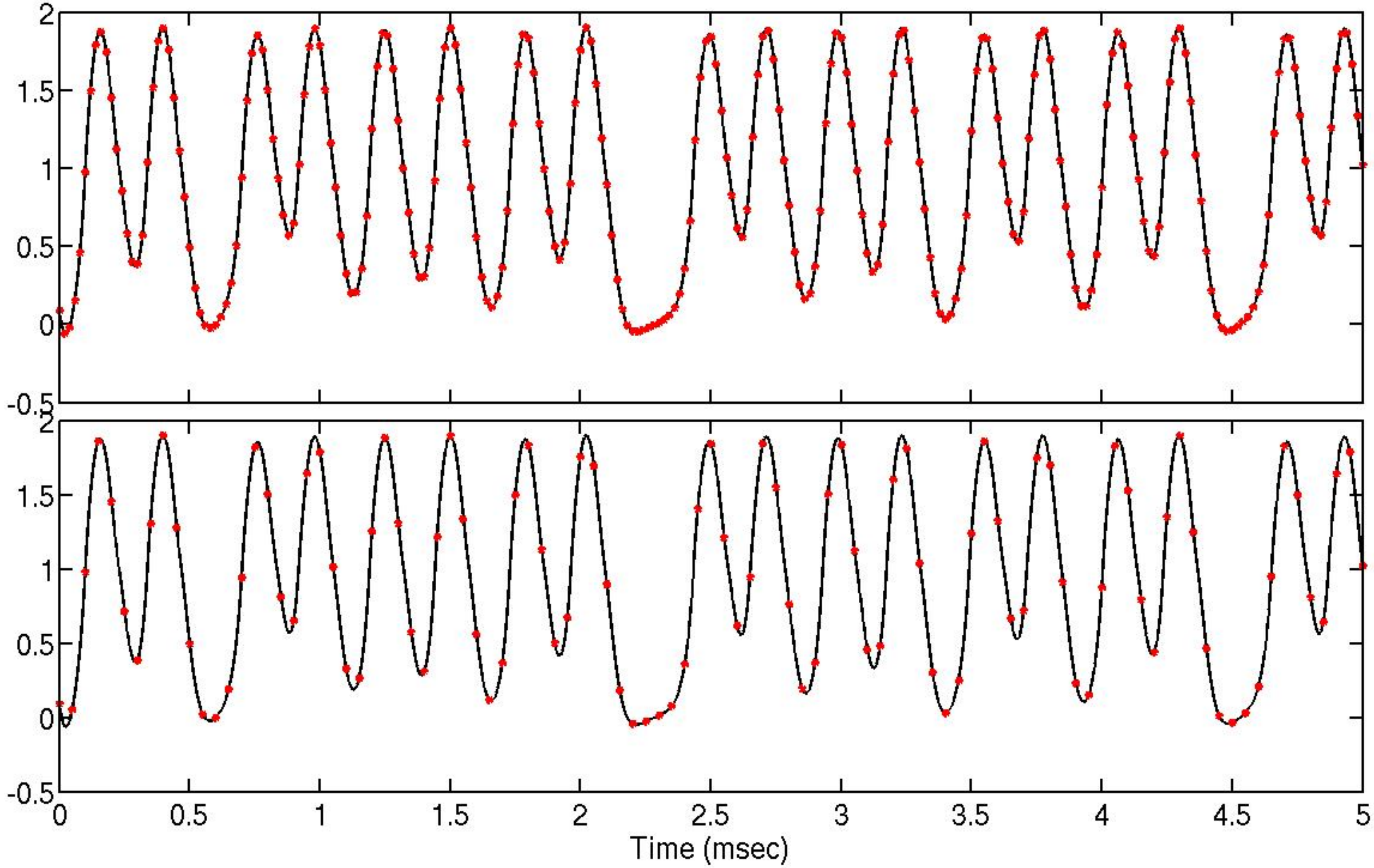
$$\frac{dZ}{d\tau} = -c[Y + r'Z] - k(3) * (Z_s - Z_{obs})$$

Pecora and Carrol (1990), PRL

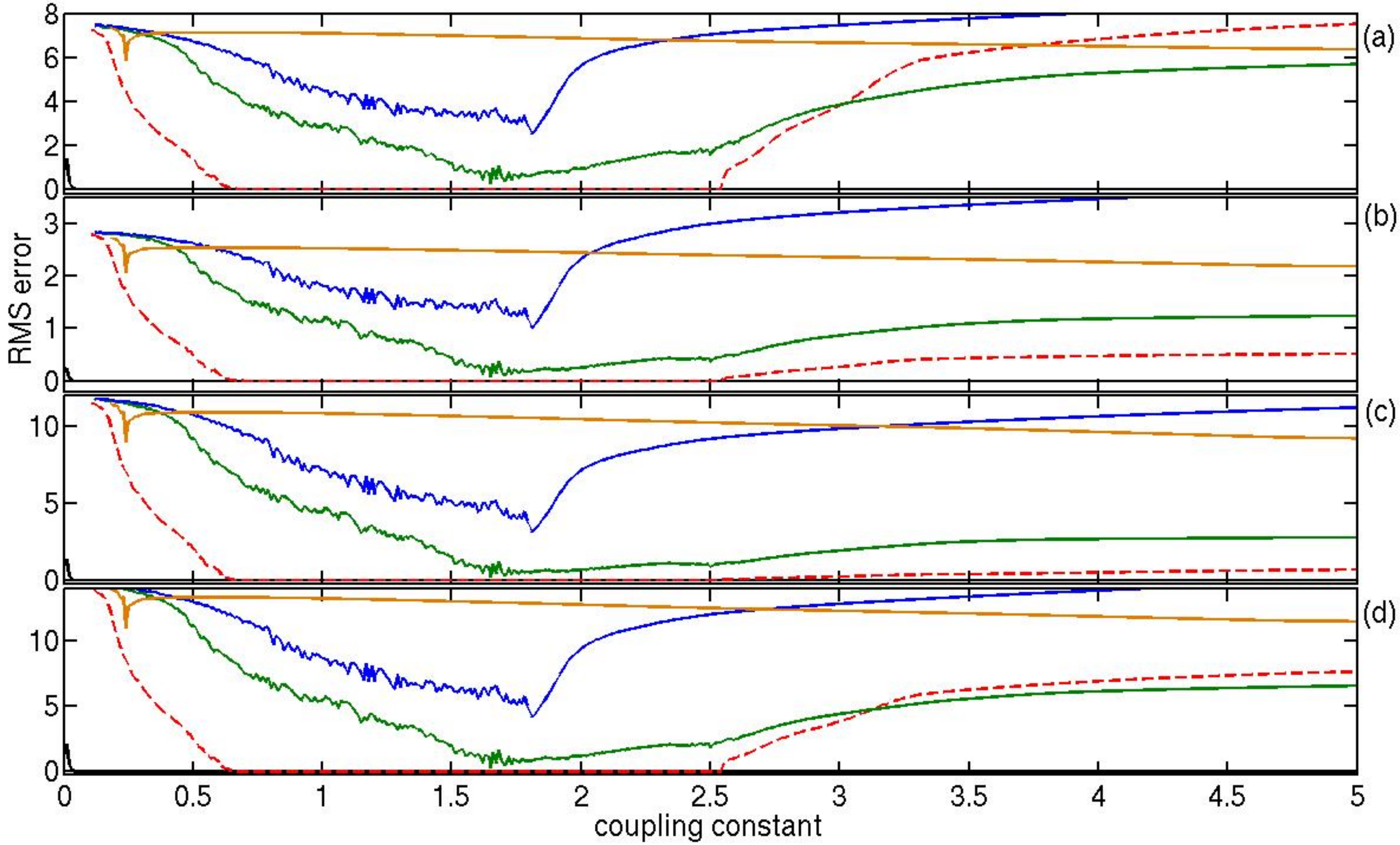

time (msec)



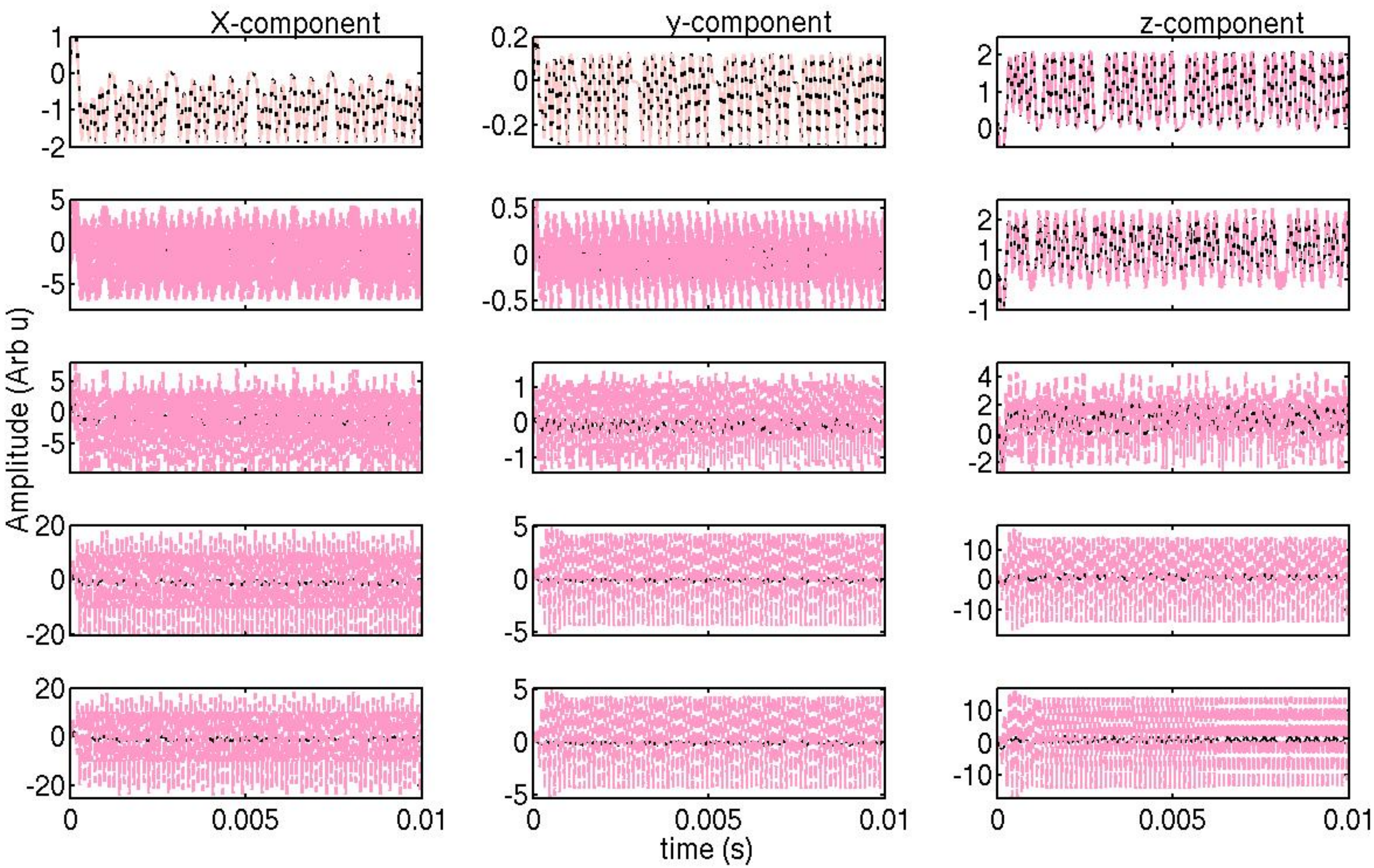
Observation

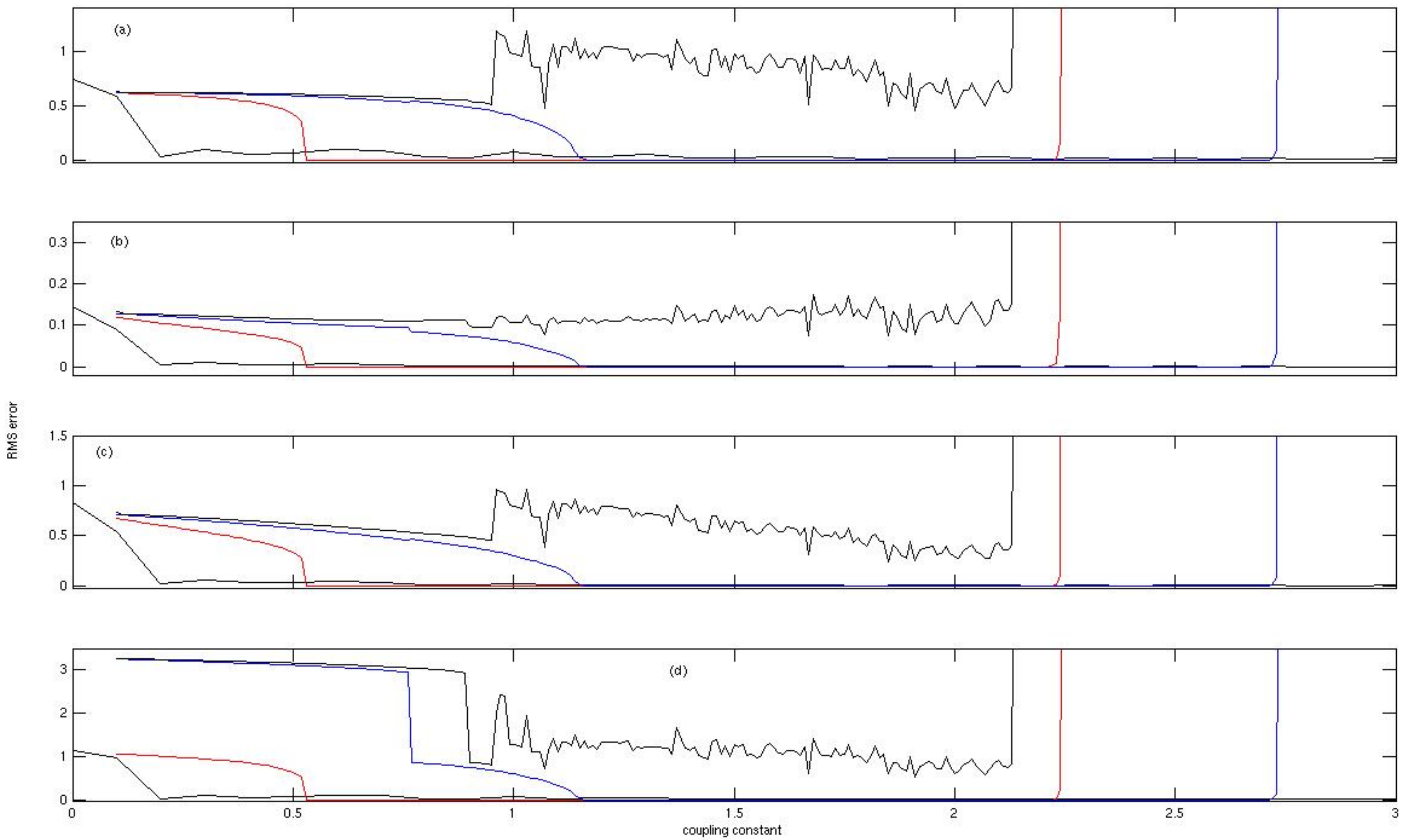


2X10^{-5}, 5X10^{-5}, 7X10^{-5}, 1X10^{-4} sec

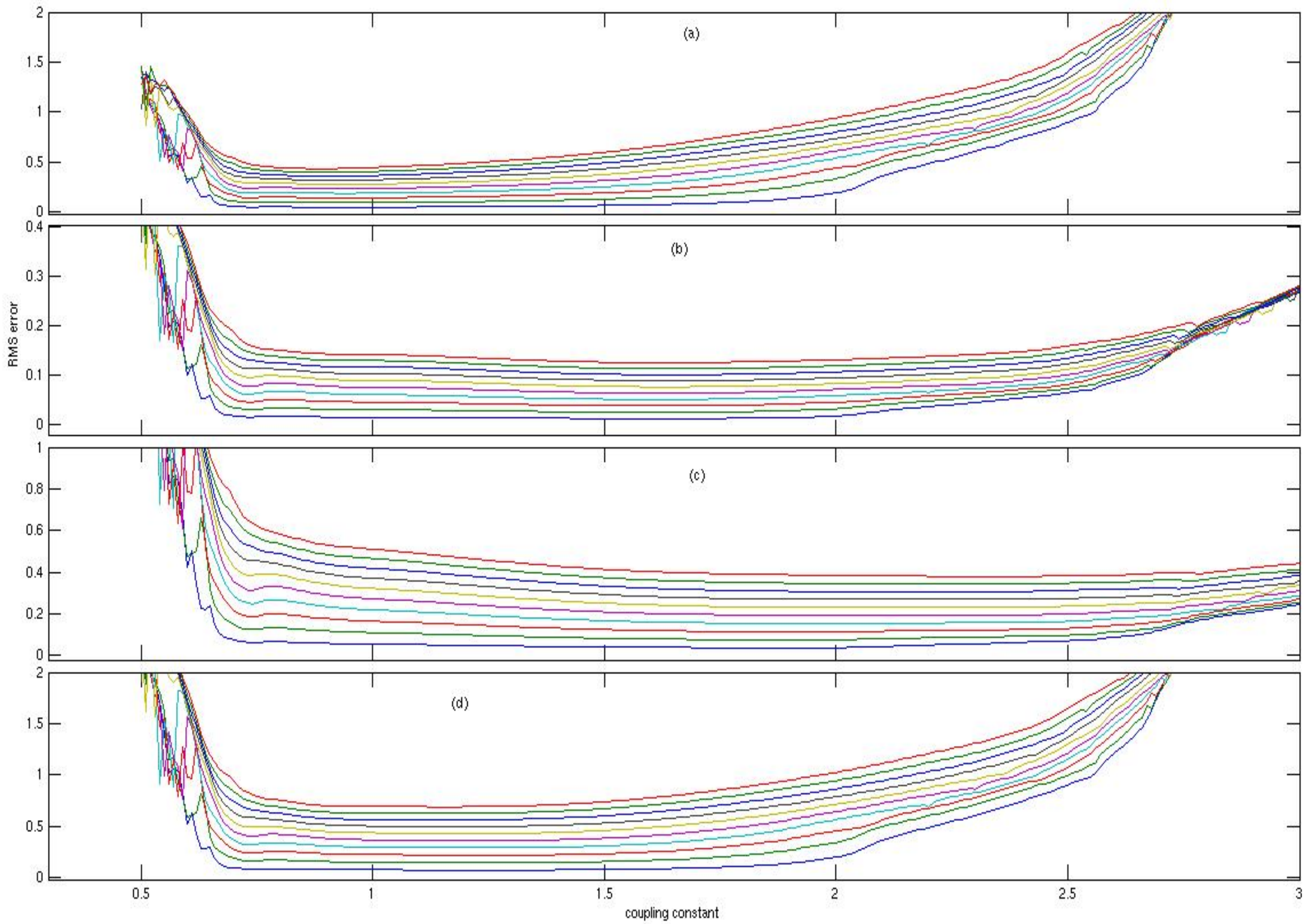


RMS error
coupling constant
(a)
(b)
(c)
(d)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

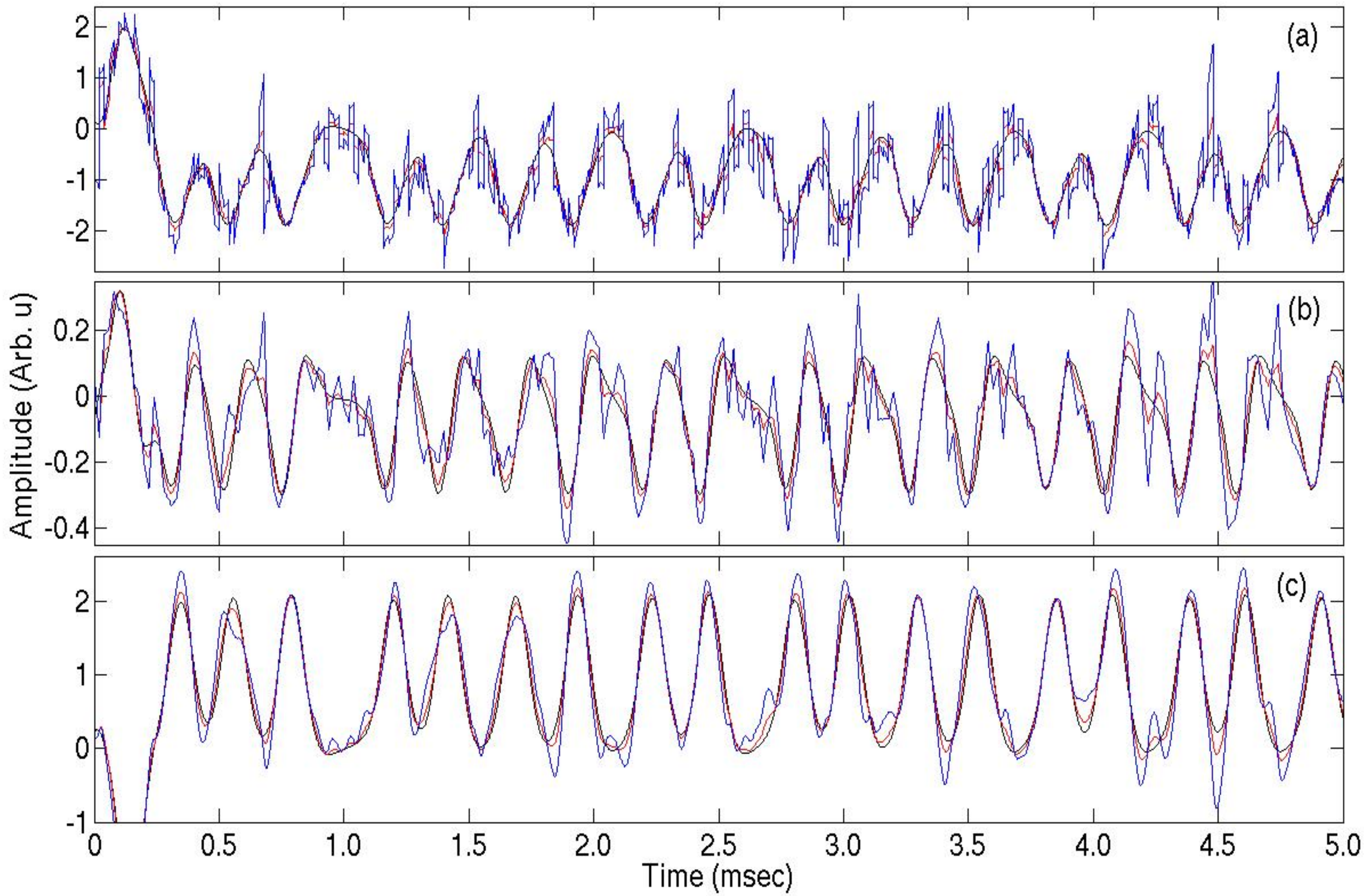

X-component
y-component
z-component
Amplitude (Arb u)
time (s)
0
0.005
0.01



(a)
(b)
(c)
(d)
RMS error
coupling constant
0
0.5
1
1.5
2
2.5
3
0.1
0.2
0.3



(a)
(b)
(c)
(d)
RMS error
coupling constant
0.5
1
1.5
2
2.5
3



(a)
(b)
(c)
Amplitude (Arb. u)
Time (msec)
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
2
1
0
-1
-2
0.2
0
-0.2
-0.4
2
1
0
-1

Discussion

1. t_{obs} should be less than Lyapunov time

2. observations are frequent

3. Observations vector is small