A centre manifold of your dynamical system

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Generally, the lowest order, most important, terms are near the end of each expression.

Specified dynamical system

$\dot{x}_1 = \sigma\varepsilon w_1 x_1 y_1 + \varepsilon^2(x_1^3 + x_1\epsilon) - \varepsilon x_1 y_1$

$\dot{y}_1 = \sigma w_1 y_1 + \varepsilon(x_1^2 + y_1^2) - y_1$

off echo;

Time dependent centre manifold coordinates

$y_1 = \sigma\varepsilon^3(4\mathrm{e}^{-1t}\star\mathrm{e}^{-1t}\star w_1\ X_1^4 - 2\mathrm{e}^{-1t}\star\mathrm{e}^{-1t}\star w_1\ X_1^2\epsilon + \mathrm{e}^{-1t}\star w_1\, X_1^4 - 2\mathrm{e}^{-1t}\star w_1\, X_1^2\epsilon) + \sigma\varepsilon\mathrm{e}^{-1t}\star w_1\, X_1^2 + \varepsilon^3(X_1^4 - 2X_1^2\epsilon) + \varepsilon X_1^2$

$x_1 = \sigma\varepsilon^2\mathrm{e}^{-1t}\star w_1\, X_1^3 + X_1$

Result centre manifold DEs

$\dot{X}_1 = -3\sigma^2\varepsilon^4\mathrm{e}^{-1t}\star w_1\, w_1 X_1^5 - 2\sigma\varepsilon^4 w_1 X_1^5 + \varepsilon^4(-X_1^5 + 2X_1^3\epsilon) + \varepsilon^2 X_1\epsilon$