

General transient solutions for the four-coupled Bloch-type equations for a two-level system

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Abstract. When the collisional dynamics of two states under consideration for a radiative transition is different, the polarization and population relaxations in gas phase at low pressure are governed by four-, instead of three-, coupled Bloch-type equations. The general transient solutions of these four-coupled equations are solved by using the Laplace transformation technique. It has been found that an additional exponential term appears because of the effect. This is also responsible for the non-exponential character in the decay signal of a transient microwave pulse experiment, besides other factors reported earlier.

Keywords. Microwave Fourier transform spectroscopy; polarization; population relaxation; Laplace transform.

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1. Introduction

1.1 Basic equations

It has been shown (Liu and Marcus 1975) that for a non-degenerate two-level system, the dynamics of the Feynman–Vernon–Hellworth (FVH) vector, \mathbf{r}' , in rotating frame, (Feynman *et al* 1957) is given by

$$d\mathbf{r}'/dt = A\mathbf{r}' + B, \quad (1)$$

where

$$\mathbf{r}' = \begin{pmatrix} (\rho'_{ij} + \rho'_{ji}) \\ i(\rho'_{ji} - \rho'_{ij}) \\ (\rho'_{ii} - \rho'_{jj}) \\ (\rho'_{ii} + \rho'_{jj}) \end{pmatrix}, \quad (2)$$

$$A = \begin{pmatrix} -1/T_2 & -\Delta w & 0 & 0 \\ \Delta w & -1/T_2 & -W_1 & 0 \\ 0 & W_1 & -\alpha_1 & -\alpha_2 \\ 0 & 0 & -\gamma_2 & -\gamma_1 \end{pmatrix}. \quad (3)$$