**DC 2.9**

- ✓ vycházíme ze vztahů

$$\left[\left(\frac{\partial}{\partial t}+\frac{1}{T_2}\right)^2+\omega_{21}^2\right]\vec{P}=-2\omega_{21}\frac{\left|\overrightarrow{d_{21}}\right|^2}{\hbar}\vec{E}N \qquad (2.79)$$

$$\vec{E}=\vec{E}_0(z,\omega)e^{i\omega t} \qquad (2.83)$$

$$\vec{P}=\vec{P}_0(z,\omega)e^{i\omega t} \qquad (2.84)$$

- ✓ (2.83) a (2.84) dosadíme do (2.79)

$$\left[\frac{\partial^2\vec{P}_0(z,\omega)e^{i\omega t}}{\partial t^2}+\frac{1}{T_2}\frac{\partial\vec{P}_0(z,\omega)e^{i\omega t}}{\partial t}+\frac{\vec{P}_0(z,\omega)e^{i\omega t}}{T_2^2}+\omega_{21}^2\vec{P}_0(z,\omega)e^{i\omega t}\right]=-2\omega_{21}\frac{\left|\overrightarrow{d_{21}}\right|^2}{\hbar}\vec{E}_0(z,\omega)e^{i\omega t}N_0$$

- ✓ po derivacích

$$\left[-\omega^2\vec{P}_0(z,\omega)e^{i\omega t}+\frac{i\omega\vec{P}_0(z,\omega)e^{i\omega t}}{T_2}+\frac{\vec{P}_0(z,\omega)e^{i\omega t}}{T_2^2}+\omega_{21}^2\vec{P}_0(z,\omega)e^{i\omega t}\right]=-2\omega_{21}\frac{\left|\overrightarrow{d_{21}}\right|^2}{\hbar}\vec{E}_0(z,\omega)e^{i\omega t}N_0$$

- ✓ zkrátíme $e^{i\omega t}$, vytkneme $\vec{P}_0$

$$\left[-\omega^2+\frac{i\omega}{T_2}+\frac{1}{T_2^2}+\omega_{21}^2\right]\vec{P}_0(z,\omega)=\left[\left(i\omega+\frac{1}{T_2}\right)^2+\omega_{21}^2\right]\vec{P}_0(z,\omega)=-2\omega_{21}\frac{\left|\overrightarrow{d_{21}}\right|^2}{\hbar}\vec{E}_0(z,\omega)N_0$$

- ✓ porovnáme koeficienty se vztahem mezi P a E:

$$\vec{P}=\varepsilon_0\chi\vec{E} \qquad (2.81)$$

$$\vec{P}_0(z,\omega)=-\frac{2\omega_{21}N_0}{\hbar}\frac{\left|\overrightarrow{d_{21}}\right|^2}{\left(i\omega+\frac{1}{T_2}\right)^2+\omega_{21}^2}\vec{E}_0(z,\omega)$$

- ✓ tedy

$$\chi(\omega)=-\frac{2\omega_{21}N_0}{\hbar\varepsilon_0}\frac{\left|\overrightarrow{d_{21}}\right|^2}{\left(i\omega+\frac{1}{T_2}\right)^2+\omega_{21}^2}$$

**DC 2.10**

- ✓ vycházíme ze vztahu

$$\chi(\omega) = -\frac{\left|\overrightarrow{d_{21}}\right|^2 N_0}{\hbar\varepsilon_0}\frac{1}{-\Delta\omega + \frac{i}{T_2}} \qquad (2.87)$$

- ✓ chceme mít výsledek ve tvaru

$$\chi(\omega) = \chi'(\omega) + i\chi''(\omega) \qquad (2.88)$$

- ✓ rozšíříme (2.87) komplexně sdruženým jmenovatelem, separujeme reálnou a imaginární část

$$\chi(\omega) = -\frac{\left|\overrightarrow{d_{21}}\right|^2 N_0}{\hbar\varepsilon_0}\frac{-\Delta\omega - \frac{i}{T_2}}{(\Delta\omega)^2 + \left(\frac{1}{T_2}\right)^2} = \frac{\left|\overrightarrow{d_{21}}\right|^2 N_0(\Delta\omega)}{\hbar\varepsilon_0\left[(\Delta\omega)^2 + \left(\frac{1}{T_2}\right)^2\right]} + i\frac{\left|\overrightarrow{d_{21}}\right|^2 N_0}{\frac{\hbar\varepsilon_0}{T_2}\left[(\Delta\omega)^2 + \left(\frac{1}{T_2}\right)^2\right]}$$

- ✓ porovnáme s (2.88)

$$\chi'(\omega) = \frac{\left|\overrightarrow{d_{21}}\right|^2 N_0(\Delta\omega)}{\hbar\varepsilon_0\left[(\Delta\omega)^2 + \left(\frac{1}{T_2}\right)^2\right]}$$

$$\chi''(\omega) = \frac{\left|\overrightarrow{d_{21}}\right|^2 N_0}{\frac{\hbar\varepsilon_0}{T_2}\left[(\Delta\omega)^2 + \left(\frac{1}{T_2}\right)^2\right]}$$