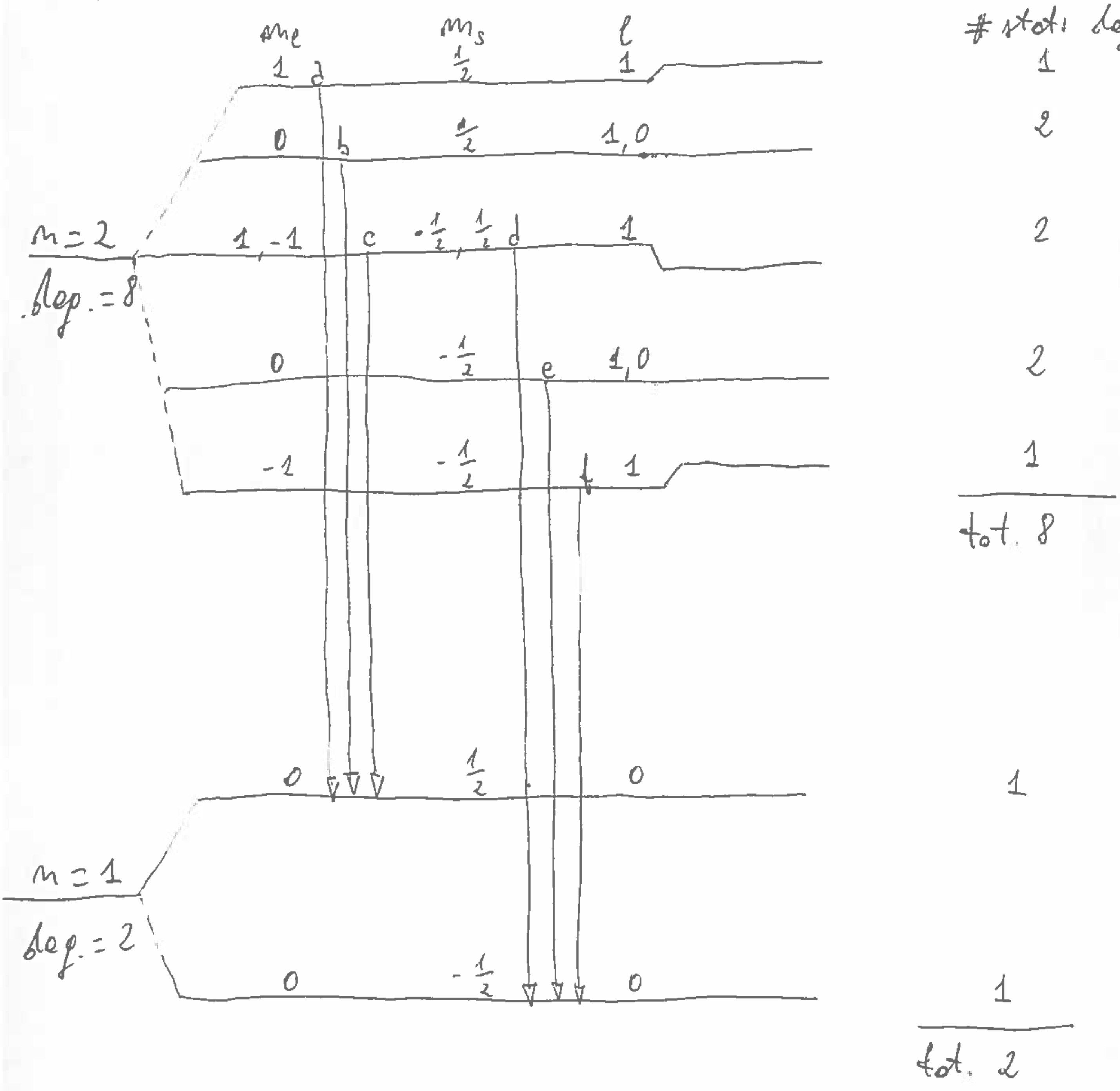
Fisica Atomica e Molecolare A.A. 2018/2019

Compito di esonero del 2 maggio 2019

Problema 1

Effetto Zeeman normale $B = 10\,T$



$$\mathcal{E}(n, \ell, m_\ell, m_s) = \mathcal{E}_n^{(0)} + \mu_B B\left(m_\ell + 2m_s\right) + \lambda_{n\ell}\, m_\ell m_s$$

$$\mathcal{E}_n^{(0)} = -R_H \frac{Z^2}{n^2} \; ; \; \lambda_{n\ell} = -\frac{\alpha^2 Z^2}{n}\, \mathcal{E}_n^{(0)} \frac{1}{\ell(\ell+\frac{1}{2})(\ell+1)}, \; \ell \neq 0$$

Regole di selezione in approssimazione di dipolo elettrico :

$$\Delta l = \pm 1 \quad ; \quad \Delta m_s = 0 \quad ; \quad \Delta m_l = 0, \pm 1$$

$$\mathcal{E}_a = \mathcal{E}_1^{(0)} - \mathcal{E}_2^{(0)} - \mu_B B - \frac{d_{21}}{2} = -82263,29 \ \text{cm}^{-1}$$

$$\mathcal{E}_b = \mathcal{E}_1^{(0)} - \mathcal{E}_2^{(0)} = \mathcal{E}_e = -82258,50 \ \text{cm}^{-1}$$

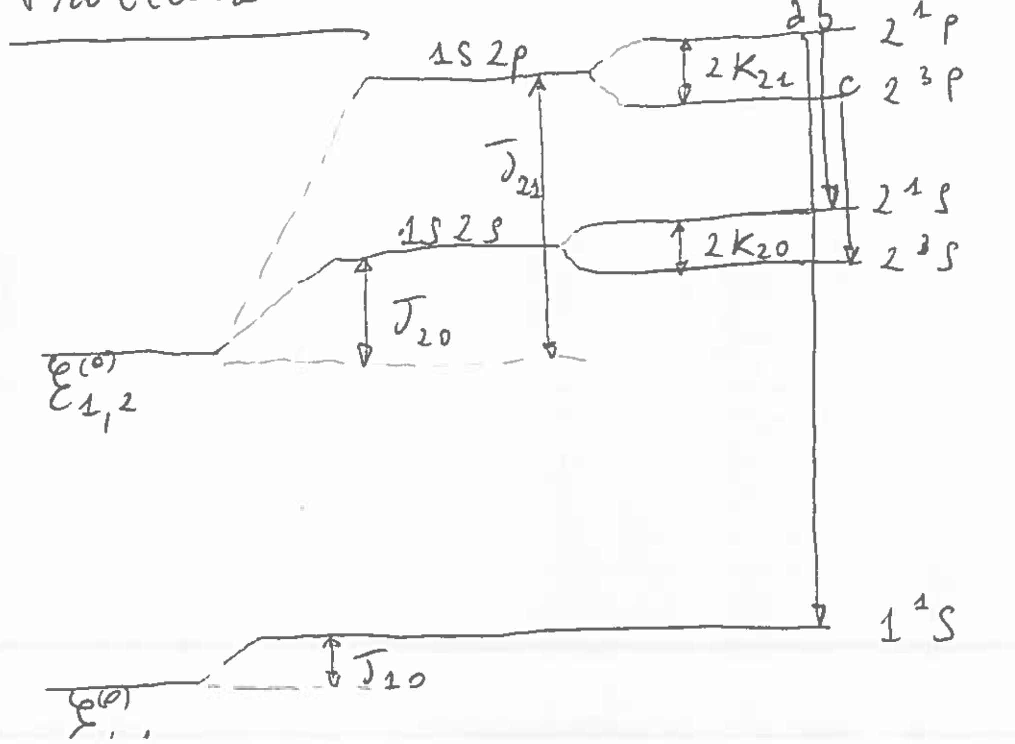
$$\mathcal{E}_c = \mathcal{E}_1^{(0)} - \mathcal{E}_2^{(0)} + \mu_B B + \frac{d_{21}}{2} = -82253,71 \ \text{cm}^{-1}$$

$$\mathcal{E}_d = \mathcal{E}_1^{(0)} - \mathcal{E}_2^{(0)} - \mu_B B + \frac{d_{21}}{2} = -82263,05 \ \text{cm}^{-1}$$

$$\mathcal{E}_f = \underbrace{\mathcal{E}_1^{(0)} - \mathcal{E}_2^{(0)}}_{\Delta\mathcal{E}_{1,2}} + \mu_B B - \frac{d_{21}}{2} = -82253,95 \ \text{cm}^{-1}$$

Con il potere risolutivo dello strumento a dispersione si possono osservare tre righe (a $\Delta\mathcal{E}_{1,2}$; $\Delta\mathcal{E}_{1,2} \pm \mu_B B$).
Si distinguono tutte le righe con $P.R \simeq 3,5 \cdot 10^5$

Problema 2



$\Delta l = \pm 1$
$\Delta S = 0$

③

$$\mathcal{E}^{(0)}_{n,n'} = -RZ^2\left(\frac{1}{n^2} + \frac{1}{n'^2}\right)$$

$$\mathcal{E}^{(0)}_{1,2} = -5R \quad ; \quad \mathcal{E}^{(0)}_{11} = -8R$$

$$\mathcal{E}(2^1P) = \mathcal{E}^{(0)}_{1,2} + J_{21} + K_{21}$$

$$K_{21} = \frac{\mathcal{E}(2^1P) - \mathcal{E}(2^3P)}{2} = 0{,}12\ eV$$

$\Longrightarrow$ $J_{21} = 10{,}08\ eV$, da cui $J_{20} = 9{,}21\ eV$

Inoltre

$$\mathcal{E}(2^1S) = \mathcal{E}^{(0)}_{1,2} + J_{20} + K_{20} \ ;$$

$$K_{20} = 0{,}38\ eV$$

$$\mathcal{E}_a = 21{,}18\ eV$$

$$\mathcal{E}_b = 0{,}61\ eV$$

$$\mathcal{E}_c = 1{,}12\ eV$$

$$\Psi(2^3P) = \frac{1}{\sqrt{2}}\left[\Psi_{100}(\vec{r}_1)\,\Psi_{21m_\ell}(\vec{r}_2) - \Psi_{100}(\vec{r}_2)\,\Psi_{21m_\ell}(\vec{r}_1)\right]$$

$$\cdot \begin{cases} \alpha(1)\ \alpha(2) \\ \frac{1}{\sqrt{2}}\left[\alpha(1)\beta(2) + \beta(1)\alpha(2)\right] \\ \beta(1)\ \beta(2) \end{cases} \qquad m_\ell = 0, \pm 1$$

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$$\Psi(2^3S) = \frac{1}{\sqrt{2}}\left[\psi_{100}(\vec{r}_1)\psi_{200}(\vec{r}_2) - \psi_{100}(\vec{r}_2)\psi_{200}(\vec{r}_1)\right].$$

$$\cdot \begin{cases} \alpha(1)\,\alpha(2) \\ \frac{1}{\sqrt{2}}\left[\alpha(1)\beta(2) + \beta(1)\alpha(2)\right] \\ \beta(1)\,\beta(2) \end{cases}$$

$$\psi_{n\ell m_\ell}(\vec{r}) = R_{n\ell}(r)\; Y_{\ell m_\ell}(\theta, \varphi)$$