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ATOM VA MOLEKULALARNING YORUG'LIKNI YUTISHI VA NURLANISHI

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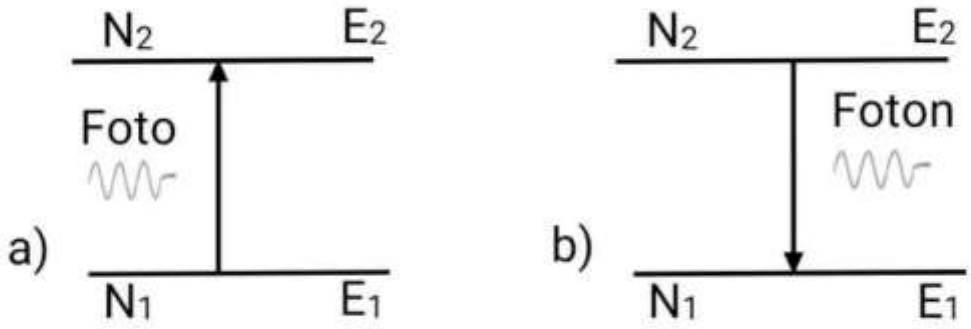
ABSTRACT

Bir xil atomlardan tashkil topgan moddani qaraymiz. Atomlar o'zaro ta'sirlashmagan hollarda, Bor postulatiga ko'ra, ikki atomlar qator energitk sathlarga ega bo'ladi.

Bir xil atomlardan tashkil topgan moddani qaraymiz. Atomlar o'zaro ta'sirlashmagan hollarda, Bor postulatiga ko'ra, ikki atomlar qator energitk sathlarga ega bo'ladi. Shu energetik sathlar 1, 2, 3,.... va hokazo tartib bilan nomerlanadi va ularga tegishli ichki energiyalar E_1, E_2, E_3.... harflari bilan belgilanadi. Shu energetik sathlardan birinchi va ikkinchisini qaraymiz va o'rganamiz. Atomning ikki energetik sathli modeli atom bilan yorug'likning o'zaro ta'sirini o'rganishni osonlashtiradi. E_1 va E_2 energetik sathlardagi atomlar sonini mos ravishda N_1, N_2 deb belgilaymiz.



1 -rasm. Atom va molekulaning ikki energetik sathlar modeli

Atom va molekulaga yorug'lik fotoni kelib tushganda (atom yoki molekula) E_1 energetik sathdan E_2 energetik sathga yorug'lik fotonini yutish natijasida o'tadi (1.a - rasmda) va ma'lum bir vaqtdan keyin E_2 energetik sathdan pastki E_1enrgetik sathga o'tish natijasida yorug'lik fotonnini (atom yoki molekula) chiqaradi (1.b-rasmda). Moddaning atom yoki molekulasiga yorug'lik fotonining o'zaro ta'sirlanishdan hosil bo'ladigan hodisalarni batafsil ko'rib chiqaylik.

Atomlarning uyg'onmagan statsionar energetik sathi pastki birinchi

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gorizontal chiziq bilan uygo'ngan statsionar energetic sathning yuqori ikkinchi gorizontal chizig'i bilan belgilanadi (1-rasmga qarang).

Agar atomga tashqaridan $h\nu_{12}$ energiyali yoruglik zarrachasi tushsa, atom o'sha zarrachani yutub, pastki energetik sathdan yuqori energetik sathga o'tadi ($E_1 \rightarrow E_2$). Bu atomning uyg'ongan holatidir. Atom $h\nu_{12}$ tashqi yorug'lik zarrachasini majburiy yutadi (1.2-b rasm) va bu majburiy o'tish bo'ladi. Atomning $E_1 \rightarrow E_2$ majburiy o'tish tashqi yorug'likning spektral energiya zichligi $\rho_\nu(\nu)$ ga va pastki sathdagi atomlar soni N_1 ga bog'liq. Bir sekund vaqt ichida birlik chostotaga mos kelgan majburiy atomlar soni quyidagicha:

$$dN_{21}=B_{12}\rho_\nu(\nu)N_1dt. \quad (1.)$$

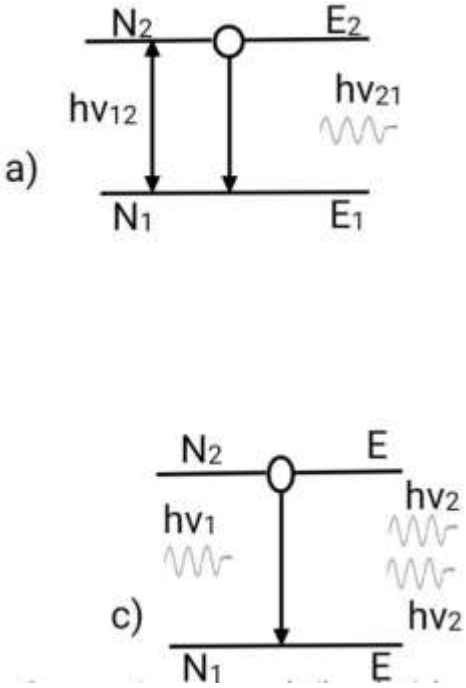
B_{12} –majburiy yutish uchun Eynshteyn koeffinsenti.

O'yg'ongan atomlar τ vaq to'tgandan keyino'z–o'zidan (spontanravishda), tashqi yorug'likning energiya zichligiga bog'liq bo'lmagan holda $E_2 \rightarrow E_1$ ga o'tadi va shu o'tishda atom o'zidan $h\nu_{21}$ yorug'lik zarrachasini chiqaradi (1-a rasm), ya'ni $E_2 - E_1 = h\nu_{21}$. Bir sekundda birlik chostotaga hisoblangan spontan o'tish soni quydagicha hisoblanadi:

$$dN_{21}^{s.n} = A_{21}N_2dt. \quad (1.1)$$

A_{21}–spontan nurlanish uchun Eynshteyn koeffisienti. Spontan nurlanishning kvant zarrachalari tartibsiz ravishda turli yo'nalishda tarqaladi .

Yuqorida ko'rib o'tilgan o'tishlardan farqli yana bir majburiy o'tish hamborligini 1916-yilda-Albert Eynshteyn aniqlagan. Agar atomlar uyg'ongan holatda bo'lsa tashqi yorug'likning spectral energiya zichligiga bog'liq ravishda o'tadi, yani $E_2 \rightarrow E_1$ va o'zidan $E_2-E_1=h\nu_{21}$ yorig'lik zarrachasini chiqaradi. Majburiy nurlanishning zarrachalari tashqi yorug'lik zarrachalari bilan birtomonga yo'naladi.



2.-rasm. Atomning uchxil nurlanish va yutilish jarayonlari ko'rsatilgana) spontan nurlanish, b) majburiyyutilish, c) majburiynurlanishyunaladi (2-c rasm).

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Majburiy nurlangan yorug'likning kvant zarrachalarining fazalari, chastotalari va yo'nalishlari qat'iy o'xshash va tartibli bo'ladi. Atomning bir sekundda birlikchostataga hisoblangan majburiynurlanishlar soni quydagi formula bilan ifodalanadi:

$$dN_{21}^{m.n}=B_{21}\rho(\nu_{21})N_2dt.$$

(1.2)

B_{12}-majburiy nurlanish uchun Eynshteyn koeffitsienti.

Energiyaning saqlanish qonuniga asosan, atomlarning $E_1 \rightarrow E_2$ga o'tishi tufayli yutilgan energiyasi spontan va majburiy nurlanishlar energiyalari yig'indisiga teng bo'lishi kerak.Shu tengliklarni quyidagicha ifodalaymiz:

$$dN^{m.yut}=dN^{s.n}\ dN^{m.n}$$

$$B_{12}\rho(\nu_{12})N_1dt=A_{21}N_2dt+B_{21}\rho(\nu_{21})N_2dt.$$

(1.3)

(1.7) formuladan quyidagi nisbatga ega bo'lamiz:

$$\frac{N_2}{N_1}=\frac{B_{12}\rho(\nu_{12})}{A_{21}+B_{21}\rho(\nu_{21})}$$

(1.4)

Koeffisientlar o'zaro tengdir : $B_{12} = B_{21}$

Normal sharoitda birlik hajmidagi atomlar soni $N=N_1+N_2$ ga teng. Termodinamik movozanatlik bajarilganda va odatdagi sharoitda energitik sathlarda atomlarning taqsimlanishi Boltiman taqsimotiga bo'ysunadi:

$$\frac{N_2}{N_1}=\frac{g_2}{g_1}\ e^{-\frac{E_2-E_1}{kt}}$$

$g_1=g_2=1$, $E_1=E_2=\Delta E$

(1.5)

$$\frac{N_2}{N_1}=e^{-\frac{\Delta E}{kt}}$$

(1.8) va (1.9) formulalardan yorug'likning sepektral energiya zichligini topamiz:

$$\rho(\nu_{12})=\frac{A_{21}}{B_{21}}\frac{1}{e^{\Delta E/kT-1}},$$

(1.6)

Formuladagi $\frac{A_{21}}{B_{21}}$ nisbat Reli–Jins formulasidan aniqlanadi va yozish mumkinki:

$$\frac{A_{21}}{B_{21}}=\frac{8\pi h\nu^3}{c^3}.$$

(1.7)

(1.10) va (1.11) formulalardan spectral energiya zichligi quydagicha aniqlanadi:

$$\rho(\nu_{12})=\frac{8\pi h\nu^3}{c^3}\frac{1}{e^{\Delta E/kT-1}}.$$

(1.8)

Shu formula absolyut qora jismning nurlanish energiya zichligini ifodalaydigan Plank formulasidir. Eynshteynning Plank formulasini keltirib chiqishidan maqsad, birinchidan, modda atomlari elektromagnit to'lqini bilan uch xil o'zaro tasirlashishini, ikkinchidan, shu uch xil jarayon ortida mustahkam matematik bog'lanish borligini va uchinchidan, majburiy nurlanish mexanizmini aniqlab berishdir. Formuladan ikki energetik sathli sistemalar uchun spontan nurlanish ehtimoliyatining majburiy nurlanish ehtimoliyatiga nisbati nurlanuvchi yorug'lik chastotasining kubinchi darajasiga proporsional ekanligi aniqlanadi. Bu esa chastotaning oshishi bilan lazer generasiyasini amalga oshirish qiyinligini bildiradi. Xullas, 1916 yilda Eynshteyn majburiy nurlanish mavjudligini va uni etiborga olish zarurligini isbotladi. Shuni aytish lozimki, jisimlarning nurlanishi tarkibida majburiy nurlanish qiymati hamisha o'lchab bo'lmaydigan va hatto alohida ajratib bo'maydigan darajada kam miqdorda mavjud.

Optikada yorug'likning intensivligi, degan kattalik bilan ish ko'riladi. Yorug'likning

intensivligi (J) elektromagnit to'lqinning amplitudasi kvadratiga (E^2) proporsional kattalikdir. U nurlanishning energiya zichligi bilan quyidagicha bog'langandir:

$$J_y=C\rho(\nu).$$

(1.9)

C=3,10^{10}cm/c yorug'likning bo'shliqdagi tezligi, J_v-o'lchov birligi J/M^2.C

XULOSA

Atom va molekulalarni uyg'otish uchun lazerlar tizimi, atomiatsiya tizimi, qayd qilish tizimi va to'lqin uzunligini va normal sharoitda birlik hajmidagi atomlar soni nazorat qilish sistemalarning ishlash jarayoni o'rganildi. Na, Cs kabi atomlaridan kuzatilayotgan selektiv ionlanish signalining intesivligiga qarab , jisimlarning nurlanishi tarkibida majburiy nurlanish qiymati hamisha o'lchab bo'lmaydigan va hatto alohida ajratib bo'maydigan darajada bog'liqligi o'rganildi.

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