FAYN, V.M.

USSR/Radiophysics - Radio-wave Propagation. Ionosphere, I-6

Abst. Journal: Referat Zhur - Fizika, No 12, 1956, 35298

Author: Zhevakin, S. A., Fayn, V. M.

Institution: None

Title: On the Theory of Nonlinear Effects in the Ionosphere

Original Periodical: Zh. eksperim. i teor. fiziki, 1956, 30, No 3, 518-527

Abstract: In the calculation of the nonlinear effects in the ionosphere, the authors use a velocity distribution function for the electrons, obtained by one of the authors (Referat Zhur - Fizika, 1956, 1313) for the case of propagation of an amplitude-modulated high frequency field of arbitrary amplitude E_0, in the presence of a permanent magnetic field. This makes it possible to calculate the values of the cross-modulation and other nonlinear ionospheric effects without assuming the magnetic field of the wave to be small, as was done earlier by other authors. It is shown that even at transmitter powers greater than 250 kw and under usual conditions of radiation and propagation of

Card 1/2

USSR/Radiophysics - Radio-wave Propagation. Ionosphere, I-6

Abst Journal: Referat Zhur - Fizika, No 12, 1956, 35298

Abstract: radio waves, a noticeable deviation occurs from the results of the approximate theory of cross-modulation (linear with respect to the square of the amplitude of the field E_0 of a strong station). Thus, in the example under consideration, at a transmitter power of 500 kw, the factor characterizing the depth of the cross-modulation, assuming collisions between the electrons and molecules, is calculated from the exact theory to be 0.465, but the linear approximation (with respect to E_0^2) results in 0.351; assuming collision with ions, this factor becomes 0.455 and 0.056 respectively. A calculation is made of the nonlinear effect of phase self-modulation, occurring upon the passage through the ionosphere of an amplitude-modulated radio-wave. It is shown that this effect amounts to several radians per second, i.e., it can be detected experimentally, and used to study the ionosphere. Bibliography, 10 titles.

Card 2/2

FAYN, V.M.

109-6-11/17

AUTHOR GINZBURG, V.L., FAYN, V.M.

TITLE On the Question of Quantum Effects on the Occasion of Interaction of Electrons with h.f. Fields in Resonators (K voprosu o kvantovykh effektakh pri vzaimodeystvii elektronov s vysokochastotnymi polyami v rezonatorakh. Russian)

PERIODICAL Radiotekhnika i Elektronika, 1957, Vol 2, Nr 6, pp 780-789 (U.S.S.R.)

ABSTRACT The problem of the quantum effects on the occasion of the passage of electrons through a hollow resonator is investigated. First the problem is treated as purely classical. The investigation is then carried out with regard to the quantum field, for which the formula of H. Nyquist (Phys. Rev., 1928, Vol 32, pp 110) is used. The authors show that this calculation is sufficient only for the determination of the energy gradient $(\Delta K_{\tau})^2$. But in order to obtain the function of the energy distribution of the electron at the resonator outlet the classical method of investigation is not sufficient. But as this method is very different from that used in the quantum theory the authors here endeavor to solve the problem by means of the introduction of canonical variables (HAMILTON method). The authors show that the simple classical calculation must be preferred. In an analogous way those cases can be investigated where the field along the way of the electron is not homogeneous. In the end the wave characteristic of the electrons are taken into account and the authors show that the elec-

Card 1/2

109-6-11/17

On the Question of Quantum Effects on the Occasion of Interaction of Electrons with h.f. Fields in Resonators

tron in the radio-range can be expressed classically and that the only quantum effect in the present work is connected with the influence of the quantum of the field and in particular with the presence of zero oscillations. This quantum effect is very small. As a summary the authors state that no quantum-mechanic methods are necessary for the calculation of the respective problems but that they can be solved by means of the quantum formula of Nyquist. (With 4 Slavic references).

ASSOCIATION "P.N. LEBEDEV" Institute for Physics of the Academy of Science of the U.S.S.R. and the GOR'KOVSKIY State University (Fizicheskiy institut im. P.N. Lebedeva An SSSR i Gor'kovskiy gosudarstvennyy universitet)

PRESENTED BY

SUBMITTED 21.9.1956

AVAILABLE Library of Congress

Card 2/2

PA - 2080

AUTHOR GINZBURG, V.L., FAYN, V.M.

TITLE On the Quantum Effects occurring on Interactions of Electrons with High Frequency Fields in Resonant Cavities (O kvantovykh effektakh pri vzaimodeystvii elektronov c vysokochastochnymi polyami v polykh rezonatorakh).

PERIODICAL Zhurnal Eksperimental'noi i Teoret. Fiziki, 1957, Vol 32, Nr 1, pp 162-164 (U.S.S.R.) Reviewed 4/1957
Received 3/1957

ABSTRACT The authors investigated the following problem in classical manner: At the moment A = 0 with the kinetic energy $K_0 = mv_0^2/2$ a non-relativistical electron enters the resonator and leaves it at the moment $t = \tau$ with the energy $K_\tau = mv_\tau^2/2$. For reasons of simplicity the electric field E in the resonator on the path of the electron is assumed to be homogeneous and parallel to the velocity of the electron (such a case is absolutely real). If $E = E_1 \cos\omega t + (E_2 + E_0) \sin\omega t$ applies, $m(dv/dt) = eE$ and $v_\tau = v_0 + (e/m\omega)\left[E_1 \sin\omega t + (E_2 + E_0)(1 - \cos\omega\tau)\right]$ is obtained. Here E_1 and E_2 denote chance quantities and $\overline{E_1} = \overline{E_2} = 0$ and $\overline{E_1^2} = \overline{E_2^2} = \overline{V^2}/d^2$ are assumed to apply. d denotes the path to be covered by the electron (thickness of the resonator) and $\overline{V^2}$ denotes the mean square of the fluctuation-voltage. The averaging is carried out over the corresponding assemblies of the identical systems. The field in the resonator is assumed to influence the movement of the electrons only to a small extent so that the terms of the order of magnitude e^2 may be taken to be sufficient. Under these circumstances $\overline{(\Delta K_\tau)^2} = e^2\overline{V^2}\left[(\sin(\omega\tau/2)/(\omega\tau/2)\right]^2$ applies. For

Card 1/2

Sum. 1319

PA - 2080

On the Quantum Effects occurring on Interactions of Electrons with High Frequency Fields in Resonant Cavities.

the dispersion of velocity then $\overline{(\Delta v_\tau)^2} = \overline{(\Delta K_\tau)^2} m^{-2} v_0^{-2}$ applies. If $\omega\tau \ll 1$, then $\overline{(\Delta K_\tau)^2} = e^2 \overline{V^2}$ applies. If oscillations of different frequencies exist in the resonator, $(\Delta K_\tau)^2 = e^2 \int_0^\infty \overline{|V_\omega|^2} [\sin(\omega\tau/2)/(\omega\tau/2)]^2 d\omega$, $\overline{V^2} = \int_0^\infty \overline{|V_\omega|^2} d\omega$ applies. For a slightly damping resonator with the frequency $\omega_0 = (LC)^{1/2}$ the following expression is found (proceeding from the general expression for $\overline{(\Delta K_\tau)^2}$): $\overline{(\Delta K_\tau)^2} = \frac{[illegible]}{C(\omega_0)} \left(\frac{\hbar\omega_0}{2} + \frac{\hbar\omega_0}{e^{\hbar\omega_0/kT}-1}\right)\left(\frac{2}{\omega_0\tau} \sin \frac{\omega\tau}{[illegible]}\right)$

Other authors found the same results by the application of the quantum-mechanical perturbation theory, their calculations, however, are more complicated and are suited only for the range of small damping. The entire quantum-like effect in the problem of the passage of an electron through a resonator is based on the consideration of the quantum-like fluctuations of radiation in the resonator and especially of the zero oscillations with the energy $\hbar\omega/2$. (Without images)

ASSOCIATION Physical Institute "P.N.LEBEDEV" of the Academy of Sciences of the USSR and the State University GOR'KIY.

PRESENTED BY

SUBMITTED 21. 9. 1956

AVAILABLE Library of Congress

Card 2/2

PA - 2981

AUTHOR FAYN V.M.

TITLE On the Problem of the Natural Width of a Line within the Radar Domain. (K voprosu o estestvennoy shirine linii v radiodiapazone.- Russian)

PARIODICAL Zhurnal Eksperim. i Teoret. Fiziki 1957, Vol 32, Nr 3, pp 607 - 608 (USSR)

Received: 6/1957 Reviewed: 6/1957

ABSTRACT If molecules are present in a volume the linear dimensions of which are much smaller than the length of the wave to be investigated, (this is realized very often in the radar domain) such molecules radiate as a uniform quantummechanical system, and the width of the line of the spontaneous radiation depends upon the quantity of the molecules. In the case of "coupled" states the width of the line is proportional to the number of molecules. The present paper shows that this result is valid also for "not coupled" states of a system of molecules. The author here investigates the practically most important case of a BOLTZMANN energy distribution of the molecules. For reasons of simplicity here only two non-degenerated energy states of the molecules are assumed. ($E_+ > E_-$). The radiation of the molecules is here examined in dipole approximation, and

CARD 1/3

On the Problem of the Natural Width of a Line within the Radar Domain.

the direct interaction of the molecules is neglected. $N_{\pm}$ be assumed to denote the number of molecules which are present in states with the energy. $E_{\pm}$. In the state of thermal equilibrium with the thermostat at the temperature T

$$n_- - n_+ \sim nE/2\,k\,T;\; n = n_- + n_+;\; E = E_+ - E_- = \hbar\omega_0$$

applies. After some further computations the following expression is found for the natural width of the line:

$$\gamma = -2\,\bar{m}\,\gamma_0 = (\hbar\,\omega/2\,k\,T)\,n\,\gamma_0.$$

Here γ_0 denotes the natural width of the line of a molecule, and, besides, $\bar{m} = -nE/4kT$ applies. At $\omega_0 = 2.10^{11}$ sec^{-1} (λ 1 cm)

$\gamma_0 = 3{,}10^{-7}$ sec^{-1} applies. This is the natural width of the line of a gas if the molecules radiate independently. If however, $\sim 10^{15}$ molecules on a stretch of ~ 1 mm (on the levels E_- and E_+),

PA - 2981

On the Problem of the Natural Width of a Line within the Radar Domain.

then $T = 300^{\circ}K$ $\gamma = 10^{5}$ sec^{1} applies at $T = 300^{\circ}$ K. Thus, the natural width of the line is in general not negligibly small within the radar domain, as was assumed. The absorption width has the same width. The phenomenon described here also has a classical analogy. In a system of oscillators which are present in a short stretch compared to the length of the radiated wave, an indirect interaction always exists owing to the common radiation field.
(No illustrations)

ASSOCIATION: State University GOR'KIY
PRESENTED BY: -
SUBMITTED: 24. 11. 1956.
AVAILABLE: Library of Congress.

CARD 3/3

FAYN, V. M.

56-2-16/47

AUTHOR: Fayn, V.M.,

TITLE: Note On the Radiation Emitted by Molecules in the Presence of a Strong High-Frequency -Field (Izlucheniye molekul v prisutstvii sil'nogo vysokochastotnogo polya).

PERIODICAL: Zhurnal Eksperim.i Teoret.Fiziki, 1957, Vol. 33, Nr 2(8),pp.416-424 (USSR)

ABSTRACT: The author at first computes this effect with the help of the correspondence principle and then discusses quantum electrodynamical considerations, which confirm the existence of this effect. The investigation on the basis of the correspondence principle: In this case the molecule is described by quantum mechanics and radiation by classical mechanics. At the outset various propositions are enumerated. The wave function of the molecule is supposed to satisfy the Schroedinger- equation $i\hbar \partial \Psi/\partial t = (H_0 + V \sin\omega t)\Psi$. With an existing interaction the solution of this equation is set up on the form $\Psi(t) = a_1 \Psi_1 + a_2 \Psi_2$. On the basis of the correspondence principle the emission and the absorption of the molecule are determined. This radiation is an essentially non equilibrium process, it takes place only under the influence of an external coercive force. The Hamiltonian in the external field is of the form $H=H_0+V \sin\omega t + W \sin\Omega t$ the equations resulting from this are also given. A weak external field with the frequency $\Omega \sim \Omega_0$ does not modify the character of the motion of the molecule, and therefore there is no resonance absorption at the frequency Ω_0. Subsequently, the

Card 1/2

Note on the Radiation Emitted by Molecules in the Presence of a Strong High-Frequency -Field. 56-2-16/47

coherence of the irradiation of single gas molecules is investigated. A two-atomic molecule is considered as an special example. With the matrix elements derivated here the intensity of radiation can be determined. Consideration on the basis of quantum-electrodynamics The occurrence of an emission at the frequency Ω_0 result from simple quantum-electrodynamical considerations. The matrix elements of the operator of the interaction with the electromagnetical field with the frequency Ω_0 (corresponding to the transition $\mathcal{E}_1 \to \mathcal{E}_2$) are proportional to $|\mu_{11} - \mu_{22}|$. The quantumelectrodynamical investigation here justifies the application of the correspondence principle. There are 6 Slavic references and no figure.

ASSOCIATION: Gor'kiy State University (Gor'kovskiy gosudarstvennyy universitet).

SUBMITTED: October 5, 1957

AVAILABLE: Library of Congress.

Card 2/2

FAYN, V.M.

56-4-19/54

AUTHOR: Fayn, V.M.

TITLE: On the Oscillation Equations of a Molecular Generator (Ob uravneniyakh kolebaniy molekulyarnogo generatora)

PERIODICAL: Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol. 33, Nr 4, pp. 945 - 947 (USSR)

ABSTRACT: The question for the oscillation equations of a molecular generator for any working regime is theoretically treated and 2 equations are established as total set of equations:

$$\ddot{E} + 4\pi \ddot{P} + (\omega_0/Q)(\dot{E} + 4\pi \dot{P}) + \omega_0^2 E = 0$$

$$\dot{N} + \mathcal{T}^{-1} N - (2/\hbar \omega_2) E(\dot{P} + \mathcal{T}^{-1} P) = \mathcal{T}^{-1} N_0,$$

where E signifies an electric field,
P - the polarization of the medium in the resonance band,
Q - the energy factor,
ω_0 - the natural oscillation of the system,
N - the number of active molecules. There are 2 Slavic references.

Card 1/2

On the Oscillation Equations of a Molecular Generator 56-4-19/54

ASSOCIATION: Gor'kiy Radiophysical Institute (Gor'kovskiy radiofizicheskiy institut)

SUBMITTED: April 20, 1957

AVAILABLE: Library of Congress

Card 2/2

Fayn, V.M.

56-5-36/46

AUTHOR: Fayn, V.M.

TITLE: On a Saturation Effect in a System With Three Energy Levels (Ob effekte nasyshcheniya v sisteme s tremya energeticheskimi urovnyami)

PERIODICAL: Zhurnal Eksperim. i Teoret.Fiziki, 1957, Vol. 33, Nr 5, pp. 1290-1294 (USSR)

ABSTRACT: In radiospectroscopy quantummechanical amplifiers and generators gain more and more in importance. In one of these devices three energy levels of paramagnetic resonance are used. The behavior of such a system with the energy levels E_1, E_2, E_3 is investigated theoretically, if it is under the influence of an alternating field, the frequencies of which are as follows:

$\omega_{31} = (E_3-E_1)/\hbar$, $\omega_{21} = (E_2-E_1)/\hbar$, $\omega_{32} = (E_3-E_2)/\hbar$.

The equation which is derived for dielectric (magnetic) susceptibility can be used quite generally in the theory of quanta-generators or amplifiers. There are 12 references, 4 of which are Slavic.

ASSOCIATION: Gor'kiy Scientific Research Institute for Radiophysics (Gor'kovskiy nauchno-issledovatel'skiy radiofizicheskiy institut)

SUBMITTED: June 10, 1957

AVAILABLE: Library of Congress

Card 1/1

FAYN, V. M. (NIRFI, Gor'kiy)

"Quantum Phenomena in the Radio Range".

The author explained the most essential results of his investigations ### for the theory of quantum systems in the radio range.

TAGER, A. S. (Moscow) and FAYN, V. M.
"Spontaneous Radiation of a Particle System, Whose Dimensions Are Comparable to the Wave Length".

report presented at the All-Union Conference on Statistical Radio Physics, Gor'kiy, 13-18 October 1958. (Izv. vyssh uchev zaved-Radiotekh., vol. 2, No. 1, pp 121-127) COMPLETE card under SIFOROV, V. I.)

ITKINA, M.A.; FAYN, V.M.

Time of relaxation caused by spontaneous radiation in the radio band. Izv.vys.ucheb.zav.; radiofiz. 1 no.3:30-36 '58. (MIRA 12:1)

1. Issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete.

(Radiation)

06465
SOV/141-1-5-6-9/28

AUTHORS: Malakhov, A.N. and Fayn, V.M.

TITLE: The Spectral Line Width of a 3-level Quantum Oscillator

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, 1958, Vol 1, Nr 5-6, pp 66 - 74 (USSR)

ABSTRACT: Quantum oscillators consist of systems with discrete energy levels, such as molecular gases, paramagnetic compounds, etc., associated with a resonator. The behaviour of the latter may be described by Eq (1) in terms of electric-field strength E , polarisation P and the resonator quality and frequency Q and ω_0 , respectively. The radiations produced suffer from three disturbing influences: thermal noise in the resonator and fluctuations in the amplitude and frequency on the pumping field. The spectral line width due to the first of these is called the "natural" line width and that due to the second and third is the "technical" line width. The effective line width is the sum of these two quantities. The resonator equation for complex field is Eq (2) and for complex permittivity is Eq (3). The latter may be

Card1/3

06465
SOV/141-1-5-6-9/28

The Spectral Line Width of a 3-level Quantum Oscillator

solved as an algebraic equation (4), which upon substitution of the changed variables immediately following it becomes Eq (5). The solutions are plotted in Figures 1-3, the permittivity being found from Eq (6). If all noise and fluctuations are absent, the amplitude and frequency of the radiation are finite vector quantities. If all disturbances are present, then Eq (18) describes the character of the radiation. If the spectral densities of the disturbances are known, Eqs (24) and (25) are expressions for the "natural" and "technical" line widths, respectively. If reasonable practical values for both gaseous and paramagnetic solid systems are substituted in these expressions it is seen that the technical line width is comparable with that of the pump source; this does not exclude the possibility that more careful examination of Eqs (22) and (23) would suggest an operating regime to give a smaller line width.

There are 3 figures and 6 references, of which 4 are Soviet and 2 English.

Card2/3

06465
SOV/141-1-5-6-9/28

The Spectral Line Width of a 3-level Quantum Oscillator

ASSOCIATION: Issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Radiophysics Research Institute of Gor'kiy University)

SUBMITTED: June 4, 1958

Card 3/3

06466
SOV/141-1-5-6-10/28

AUTHOR: Fayn, V.M.

TITLE: On the Theory of a "Cohetron"

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, 1958, Vol 1, Nr 5-6, pp 75 - 82 (USSR)

ABSTRACT: The device described was proposed by the author in his earlier works (Refs 3,4). The principle of the device is as follows. A system of quantum objects having two energy levels is excited by some means; the objects will, therefore, spontaneously radiate energy quanta $h\omega = E_2 - E_1$, where E_2 and E_1 are the energy levels of the objects. In particular, a cohetron can be based on a system of electrons, since an electron in a magnetic field has two energy states (depending on the direction of the magnetic moment of the electron). The aim of this paper is to analyse the operation of an electron-type cohetron. If the electrons are situated in a magnetic field, the overall magnetic moment $\vec{\mu}$ of the system obeys:

Card1/5

06466

SOV/141-1-5-6-10/28

On the Theory of a "Cohetron"

$$\frac{d\vec{\mu}}{dt} = \gamma\left[\vec{\mu}\underline{H}\right] + \frac{2\gamma}{3c^3}\left[\vec{\mu}\,\vec{\mu}\right] - \frac{1}{\tau}\left[\vec{\mu} - \vec{\mu}_o(t)\right] \qquad (1)$$

where γ is the gyro-magnetic ratio, g is the spectroscopic splitting coefficient, μ_B is the Bohr magnetron, $\vec{\mu}_o$ is the instantaneous equilibrium value of $\vec{\mu}$, corresponding to the field H, τ is the relaxation time and c is the velocity of light. The first term in Eq (1) describes the action of the external field H, the second term takes into account the internal magnetic field of the system, while the third term describes the change of $\vec{\mu}$ due to the relaxation processes. It can be assumed that the components μ_x and μ_y of Eq (1) are sinusoidal functions of time, their frequency being $\omega = \gamma H$. The above assumption leads to Eqs (5) and (6). If a new variable φ is introduced, as defined by Eq (7) and if $\vec{\mu}_o$ obeys Eq (8), Eqs (5) and

Card2/5

(6) can be written as:

$$\dot{\varphi} = -\left[\frac{2\gamma}{3c^3}(\gamma H)^5 \mu + \frac{\varkappa H}{\mu \tau}\right]\sin\varphi \qquad (9)$$

$$\dot{\mu} + \frac{1}{\tau}\mu = \frac{\varkappa H}{\tau}\cos\varphi \qquad (10)\,.$$

These are the basic equations for the investigation of the system. If it is assumed that the relaxation time is comparatively long, that is, $t \ll \tau$, Eqs (9) and (10) can be written as Eq (11). Integration of Eq (11) leads to Eq (12). The intensity of the radiation of the system is given by Eq (13). On the basis of Eq (12), the intensity of the radiation can be written as Eq (15). If the magnetic field changes stepwise (as shown in Figure 1), the radiation intensity can be described by

06466
SOV/141-1-5-6-10/28

On the Theory of a "Cohetron"

Eqs (16) and (16'). On the other hand, when H is given by Eq (17), where $\Omega \ll \omega$, the radiation is expressed by Eq (18). For $t \gg \tau$, the solution of Eq (10) is in the form of Eq (23), where ξ is given by Eq (24); it is assumed in the above that the magnetic field H is given by Eq (17). The energy radiated by the system during one change-over cycle of the magnetic field is given by:

$$E = 2r\hbar\omega = \left| n_1 - n_2 \right| \hbar\omega \qquad (29)$$

where n_1 and n_2 is the equilibrium difference in the populations of the levels E_1 and E_2. The average radiation power is given by Eq (30), where T denotes the period of the magnetic field. On the basis of the above formulae, it is found that at a wavelength of 1 cm it is possible to obtain peak pulse powers of 3×10^5 W in a cohetron using a ferrite.

Card4/5

On the Theory of a "Cohetron"

06466
SOV/141-1-5-6-10/28

There are 1 figure and 11 references, of which 5 are English and 6 Soviet; one of the Soviet references is translated from English.

ASSOCIATION: Issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Radiophysics Research Institute of the Gor'kiy University)

SUBMITTED: May 29, 1958

Card 5/5

RUMANIA/Radio Physics - Applications of Radiophysical Methods. I

Abs Jour : Ref Zhur Fizika, No 10, 1959, 23420

Author : Fain, V.M.
Inst :
Title : Quantum Phenomena in the Radio Band

Orig Pub : An. Rom.-Sov. Ser. mat.-fiz., 1958, 12, No 4, 47-94

Abstract : Translation from the Journal "Uspekhi Fiz. Nauk" 1958, 64, No 2.
See Referat Zhur Fizika, 1958, 10, 23638.

Card 1/1

56-34-4-54/60

AUTHOR: Fayn, V. M.

TITLE: On the Spontaneous Radiation of a Paramagnetic Substance in a Magnetic Field (O spontannom izluchenii paramagnetika, nakhodyashchegosya v magnitnom pole)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol. 34, Nr 4, pp. 1032 - 1033 (USSR)

ABSTRACT: Based upon a theory suggested in this paper the following process is suggested for the excitation of the electromagnetic radiation by means of a paramagnetic substance in a magnetic field: The paramagnetic substance is to be brought into a magnetic field. The electrons of the paramagnetic substance have then 2 energy levels the difference of which is $E_2 - E_1 = \hbar\omega = g\beta H$. β denotes the Bohr's magneton, g a factor of the magnitude 1 and H the magnetic field intensity. When the temperature of the paramagnetic substance is almost equal to zero the magnetic moments of all electrons adjust themselves to the magnetic field. This will be the lowest state of the system; then the magnetic field is connected in such a way that its direction reverses. Such a transformation must be sufficiently quick with respect to the duration τ of the thermal

Card 1/3

On the Spontaneous Radiation of a Paramagnetic Substance in a Magnetic Field 56-34-4-54/60

relaxation and the duration of radiation $\tau_{r,0}$, and, besides, sufficiently slow with respect to the period of radiation $\tau_{radiation} = 2\pi/\omega$. After such a transformation of the magnetic field all electrons are in a higher state of energy. When the size of the paramagnetic substance is much smaller than the wave of the radiated waves the system passes over into a higher state of radiation according to the time $\tau_{r,0}$. For the intensity of the radiation holds $I = \omega^4 |\mu_{1,2}|^2 n/3c^3$, with $\mu_{1,2}$ denoting the dipole moment of the transition 1 - 2. According to time $2\tau_{r,0}$ the system radiates its entire energy (equal to $A = n\hbar\omega$) and passes over into a lower state of energy. Then the magnetic field is connected once more and the system starts radiating again. If the magnetic field with the frequency $f \sim (1/2)(\tau_H + 2\tau_{r,0})$ changes, the system radiates an average power of the magnitude $W = n\hbar\omega/(\tau_H + 2\tau_{r,0})$. Then the author represents some numeric evaluations. By making

Card 2/3

On the Spontaneous Radiation of a Paramagnetic Substance in a Magnetic Field 56-34-4-54/60

use of the Stark-effect it is possible to produce in an analogous way a radiation in an electric field. At the end the author thanks Professor V.L.Ginzburg for the discussion of this paper. There are 3 references, 2 of which are Soviet.

ASSOCIATION: Gor'kovskiy radiofizicheskiy institut (Gor'kiy Radiophysical Institute)

SUBMITTED: January 24, 1958

1. Magnetic materials--Electromagnetic properties

Card 3/3

21(8) SOV/56-35-3-54/61

AUTHOR: Ginzburg, V. L., Fayn, V. M.

TITLE: On the Radiation of Systems With Many Levels Which Move in a Medium With Super-Light-Velocity (Ob izluchenii sistem s mnogimi urovnyami, dvizhushchikhsya v srede so sverkhsvetovoy skorost'yu)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 3, pp 817 - 818 (USSR)

ABSTRACT: The present paper deals with interesting possibilities offered in connection with systems of many levels moving with a velocity greater than that of light. If, initially, the system was on a single level (e.g. the lowest energy level) it will be possible, in the course of time, to observe it in all those states into which it may pass over by direct or cascade-like radiation transition. Formulae are given for the degree of occupation of the levels and for the energy emitted into the unit solid angle in the unit of time. To the systems which have many levels there also belong the bunches of atoms or molecules with two suitable levels. The radiation of such bunches (which have dimensions smaller than the wave length)

Card 1/2

On the Radiation of Systems With Many Levels Which Move in a Medium With Super-Light-Velocity SOV/56-35-3-54/61

is coherent with and similar to the radiation of a system in a magnetic field. However, the radiation (with a velocity greater than that of light) of such bunches as well as of single atoms and molecules or of para- and ferromagnetic particles is of hardly any practical importance. However, the radiation (with a velocity greater than that of light) of electrons moving along a magnetic field is perfectly real. In this connection, a metallic slowing-down system but also a dielectric or a plasma located near the bundle can play the part of this medium. Next, some details connected with this phenomena are given. A more detailed report on this Doppler-radiation of electrons moving with a velocity greater than that of light is intended to be given at a later date. There are 9 references, 8 of which are Soviet.

ASSOCIATION: Gor'kovskiy gosudarstvennyy universitet (Gor'kiy State University)

SUBMITTED: June 30, 1958

Card 2/2

53-2-2/5

AUTHOR: Fayn, V. M.

TITLE: Quantum Phenomena Within the Radio Frequency Range (Kvantovyye yavleniya v radiodiapazone)

PERIODICAL: Uspekhi Fizicheskikh Nauk, 1958, Vol. 64, Nr 2, pp. 273-313 (USSR)

ABSTRACT: The first section deals with quantum phenomena in radio-electronics. The point in question are the quantum phenomena, which occur in resonators in the interaction of the electrons with high-frequency fields. The author starts out with a semi-classical investigation taking into consideration the quantum-caused background noise in resonators. This is followed by a discussion of the effects, which are connected with the quantization of the electric field, where the electron is described by classical theory. The derivation given here of the formula for the quantum-like dispersion of the electron energy proves the correctness of the aforementioned semi-classical derivation. The formula obtained here for the quantum-like dispersion of electron energy is compared with the formulae found in publications. The effects

Card 1/2

Quantum Phenomena Within the Radio Frequency Range 53-2-2/5

are considered, which are connected with the quantum-like character of the motion of the electron. Within the radio-frequency range it is possible to describe the electron in a classical manner, and the only quantum effect in the problem under consideration is connected with the influence of the quantisation of the field, and in particular with the existence of zero oscillations. It is very small. The second section deals with a few problems of radiospectroscopy, which hitherto have never been considered in publications. At first the peculiarities are enumerated and then discussed, by which radiospectroscopy differs from optical spectroscopy. The following paragraphs investigate some quantum effects, which are connected with the aforementioned peculiarities of radiospectroscopy. The points in question are the problem of coherence in the spontaneous emission, of the natural line width within the radiofrequency range, the generation of microradiowaves and of the radiation of molecules in an intense high-frequency field. There are 2 figures, 1 table, and 77 references, 23 of which are Slavic.

AVAILABLE: Library of Congress

Card 2/2

1. Resonators-Noise 2. Electrons-Motion 3. Radio ranges-Mathematical analysis

05479
SOV/141-2-2-4/22

AUTHOR: Fayn, V.M.

TITLE: Interaction of a Two-level System of Particles with the Radiation Field in Free Space and in Resonators

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, 1959, Vol 2, Nr 2, pp 167 - 180 (USSR)

ABSTRACT: A system of identical quantum particles having two energy levels is considered. The system consists of molecules and interacts with its own and an external radiation field. If the interaction between the molecules is neglected, the Hamiltonian of the system can be written in the form of Eq. (1), where H_o^j is the Hamiltonian of a free molecule having eigen values $h\omega_o/2$ and $-h\omega_o/2$; p_λ and q_λ represent the impulse and the co-ordinate of the radiation oscillator, respectively. $\underline{A}(\underline{x})$ is the vector-potential of the electromagnetic field, which is given by Eq (2); $\underline{A}_\lambda(\underline{x})$ represent normalised vector functions; $\underline{\mu}_j$ is the dipole moment of the (electrical or magnetic) j-th molecule. The third term in Eq (1) represents the

Card1/9

05479
SOV/141-2-2-4/22

Interaction of a Two-level System of Particles With the Radiation Field in Free Space and in Resonators

interaction energy between the field and the molecules. It is possible to introduce for the system an energy spin for a particle. This is in the form of a vector operator $\underline{r}(r_1, r_2, r_3)$ in a certain space R. The components of the vector $\underline{r}$ obey the relationships given by Eqs (3) and (4). The operators H_o^j and $\dot{\mu}$ can now be written in the form of Eqs (5). The Hamiltonian of Eq (1) can therefore be written as Eq (6), where $\underline{a}$, $\underline{e}_1$, $\underline{e}_2$ and $\underline{e}_3$ are constants depending on the type of the molecule. Since the derivative of the operator $\hat{A}$ is given by Eq (8), the equations of motion for the operators $\underline{r}$ and the field operators are in the form of Eqs (9)-(12). In the following, only the case when $\underline{a} = 0$ and $\underline{e}_3 = 0$ is considered. If it is assumed that the distribution of electric spins is continuous, their density at a given point $\underline{x}$ can be represented by $s_1(\underline{x})$, $s_2(\underline{x})$ and $s_3(\underline{x})$.

Card2/9

05479
SOV/141-2-2-4/22

Interaction of a Two-level System of Particles With the Radiation Field in Free Space and in Resonators

The total spin of the system is given by Eqs (13), while the equations of motion for s_1, s_2, s_3 and q_λ are in the form of Eqs (14). Eqs (14) are the formulae of the classical physics and are analogous to the corresponding equations for the magnetic moment in a magnetic field. When the particles are distributed in a volume whose linear dimensions are much smaller than the wavelength of the radiated energies, Eqs (14) can be written as Eqs (15). If the equations are solved for the case when the molecules are situated in a free space, the results obtained are those relating to the coherent spontaneous radiation, as indicated in the article of R.H. Dicke (Ref 1). In Eqs (14) and (15), it is possible to take into account the effect of the collisions between the molecules and the losses in a resonator. These effects are represented by three constants, T_1, T_2 (longitudinal and transverse relaxation times) and Q which represents

Card3/9

the quality factor of the resonator. The system is now described by Eqs (17), where s_3^0 is the equilibrium value of s_3. If the molecules are situated in an ideal resonator, having $q = \infty$, Eqs (15) can be written as:

$$\dot{r}_+ = \alpha q R_3 e^{-i\omega_o t} ; \quad \dot{r}_- = \alpha^* q R_3 e^{i\omega_o t} ;$$

$$\dot{R}_3 = -\frac{1}{2} (\alpha^* r_+ e^{i\omega_o t} + \alpha r_- e^{-i\omega_o t}) q ; \tag{19}$$

$$\ddot{q} + \omega^2 q = \frac{i\hbar}{2} \left[\alpha^* r_+ e^{i\omega_o t} - \alpha r_- e^{-i\omega_o t}\right]$$

where the notation defined by Eqs (18) is introduced. Eqs (19) are solved for a number of special cases. When q is a known function of time, these solutions are in the

05479

SOV/141-2-2-4/22

Interaction of a Two-level System of Particles With the Radiation Field in Free Space and in Resonators

form of Eqs (20). When q is a known function of time and the system is at resonance, the solutions are given by Eqs (21) and (22). In the case of a true resonance, it is assumed that the oscillation q is amplitude-modulated and is represented by Eq (23). Eqs (19) are now in the form of Eqs (24) and (25). The solution for R_3 is given by Eqs (26) so that the final expression is in the form of Eq (28). When the resonator has a finite Q , Eq (28) is modified and takes the form of Eq (29). The problem of the radiation of a single molecule in a resonator can be approached in terms of quantum physics. A molecule having two energy levels E_+ and E_- is situated in a resonator whose natural frequency corresponds to:

$$\omega_o = (E_+ - E_-)/\hbar \qquad (30).$$

Card5/9

05479

SOV/141-2-2-4/22

Interaction of a Two-level System of Particles with the Radiation Field in Free Space and in Resonators

If the resonator is represented by an equivalent circuit having a capacitance C and a quality factor Q_R, the Hamiltonian of the system is in the form of Eq (31). It is now necessary to find the solution of the Schroedinger equation for the system. By employing the usual methods (V. Heitler - Ref 11), the equations for the probability amplitudes b are in the form of Eqs (33). By a suitable substitution, Eqs (33) can be transformed into Eqs (35) and (36). Another substitution results in the final expression:

$$\ddot{v} + \frac{V^2}{\hbar^2} v + \gamma \dot{v} = 0 \qquad (38)$$

where γ is given by Eq (39). The solution of Eq (38) is in the form of the last equation on p 176. On the basis of the quantum physics, a system containing a large number of molecules can be represented by quantum numbers

Card6/9

05479
SOV/141-2-2-4/22

Interaction of a Two-level System of Particles with the Radiation Field in Free Space and in Resonators

r and m and the absolute value of the energy spin and its projection onto the axis R_3. It is shown that the average energy of the field is governed by the following expression:

$$E(t - t_o) = h\omega_o \left| H'_{+-} \right|^2 h^{-2} (r + m)(r - m + 1)(t - t_o)^2 \quad (43a).$$

It is now necessary to determine the energy E by employing the classic equation, i.e. Eq (29). This can be written as Eq (29a), where φ represents the small change of the angle ϑ in the vicinity of $\mathfrak{J}$. The solutions of Eq (29a) are given by Eqs (46) and (47). The field amplitude and the energy E are represented by :

$$q_o = \hbar \sqrt{h/2\omega_o} \left| H' \right|^{-1} \dot{\varphi} \quad (49)$$

Card7/9 and

Interaction of a Two-level System of Particles with the Radiation Field in Free Space and in Resonators

$$E = \frac{\omega_o^2 q_o^2}{2} = \frac{1}{4} h\omega_o \frac{\hbar^2}{|H'|^2} \dot{\varphi}^2 \qquad (50)$$

For the time intervals obeying the conditions of Eq (44) it is found that the energy is given by Eq (51). In order to obtain a correspondence between Eqs (51) and (43a), it is necessary to assume that Eqs (52) are valid. Consequently, the radiation energy is given by Eq (55). When A = 0 , the total radiation energy is expressed by Eq (56). Eq (55) (or 56) determines the noise in masers. There are 13 references, of which 8 are English and 5 Soviet; one Soviet reference is translated from English.

05479
SOV/141-2-2-4/22

Interaction of a Two-level System of Particles with the Radiation Field in Free Space and in Resonators

ASSOCIATION: Issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Radiophysics Research Institute of Gor'kiy University)

SUBMITTED: November 24, 1958

Card 9/9

80124

24.7900

S/141/59/002/06/005/024
E032/E314

AUTHOR: Fayn, V.M.

TITLE: The Radiation of Ferrimagnetic Systems

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, 1959, Vol 2, Nr 6, pp 876 - 883 (USSR)

ABSTRACT: In previous papers the author showed that adiabatic remagnetization of a ferromagnetic or paramagnetic specimen gives rise to a coherent spontaneous emission of radiation at a frequency corresponding to the ferromagnetic (paramagnetic) resonance. In the present paper the author investigates the behaviour of ferrimagnetic systems in the presence of an alternating field. It is shown that such systems can be used to produce radiation at a frequency which is greater than that obtained during the remagnetization of an ordinary ferromagnetic. If the ferrimagnetic consists of two sub-lattices with magnetization vectors $\underline{M}_1$ and $\underline{M}_2$, then the equations of motion are of the form given by Eq (1), where $\underline{H}_o$ is the external magnetic field, $\underline{H}_{1A}$ and $\underline{H}_{2A}$ are the anisotropy fields in the first and second sub-lattices, $\underline{H}_{1E}$ and $\underline{H}_{2E}$ are the fields of exchange

Card1/3

80124

S/141/59/002/06/005/024
E032/E314

The Radiation of Ferrimagnetic Systems

forces and γ_1 and γ_2 are the gyromagnetic ratios. Near the compensation point $(S = 0, \underline{S} = \underline{M}_1/\gamma_1 + \underline{M}_2/\gamma_2)$ an alternating magnetic moment having a frequency determined by the ratio H_E/H_o appears when the ferrimagnetic is subjected to a sinusoidal alternating magnetic field (H_E is the intensity of the molecular field). This frequency is greater by at least an order of magnitude than γH_0. The frequency is practically independent of the frequency of the external alternating magnetic field and increases with the amplitude of H_0. Various applications are suggested for ferrimagnetics with compensation points (sharp high frequency pulses, electromagnetic shock waves). Acknowledgments are made to S.I. Al'beru and T.N. Pigolkina. There are 7 figures and 7 references, 6 of which are Soviet and 1 is English.

Card2/3

4

80124
S/141/59/002/06/005/024
The Radiation of Ferrimagnetic Systems E032/E314

ASSOCIATION: Nauchno-issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Scientific-research Radiophysics Institute of Gor'kiy University)

SUBMITTED: July 16, 1959

4

Card 3/3

24(8)

AUTHOR: Fayn, V. M. SOV/56-36-3-21/71

TITLE: On the Theory of Coherent Spontaneous Radiation (K teorii kogerentnogo spontannogo izlucheniya)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 3, pp 798-802 (USSR)

ABSTRACT: Treatment of the spontaneous emission of a system of particles, the dimensions of which are very large compared to the wave length of the emitted wave, makes it necessary to take the coherence between the emitted individual particles (Mandel'shtam, Ref 1)(Refs ., 2-5) into account. In theoretical investigations the fact has hitherto not been taken into consideration that every particle is located in the quasisteady field of the near zone of all other particles. Consideration of interaction may lead to a variation of the eigenfrequency of the system (references 3 and 5 consider only that part of interaction which leads to a widening of emission lines, without considering the possibility of a shifting of eigen-frequency). The author of the present paper investigates this problem, in consideration of particle interaction, by way of the general radiation field. First, a system of particles with

Card 1/3

spin- and magnetic moment and located in an external magnetic field (electrons) is investigated by the classical method (according to Ginzburg)(Ref 10). In the following, the occurrence of a frequency shift is investigated by the quantum-theoretical method. It is found that this consideration basically leads to a shifting of the eigenfrequency

$\Delta_1\omega = (4\omega_m\ \omega_o^2 / 3\pi c^3)\gamma\mu_z$ and to a width of line

$\Delta_2\omega = \omega_o^3\gamma\mu / 3c^3$. ($\gamma$ denotes the gyromagnetic ratio, μ the magnetic moment, and $\omega_m = c/R$, where R is of the order of magnitude of the radius of the system). The frequency shift is $\omega_m / \omega_o \sim \lambda/R$ times as great as the width of the radiation lines.

On the Theory of Coherent Spontaneous Radiation [illegible]

This frequency shift might be determined experimentally in the course of the investigation of the radiation of ferromagnetics, antiferromagnetics, or crystals which have corresponding energy levels in the r.f.- range. There are 15 references, 10 of which are Soviet.

ASSOCIATION: Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Radiophysical Institute of Gor'kiy State University)

SUBMITTED: June 30, 1958

Card 3/3

BULAYEVSKIY, L.N.; FAYN, V.M.; FREYDMAN, G.I.

Instability of the homogenous precession of magnetization. Zhur. eksp. i teor. fiz. 39 no.2:516-517 Ag '60. (MIRA 13:9)

1. Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta.

(Ferromagnetism)

86905

S/056/60/039/005/022/051
B006/B077

24.7900 (1035,1144,1160)

AUTHORS: Ginzburg, V. L., Fayn, V. M.

TITLE: Theory of Ferro- and Antiferromagnetism

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 5(11), pp. 1323-1338

TEXT: A simple approximate method is developed which permits determining the magnetization of the lattice or sublattice and also other quantities of ferro- and antiferromagnetics practically throughout the complete temperature range as functions of the dimensions and shape of the magnetic system. By way of introduction the authors point out the importance of the magnetic methods in the investigation of fine disperse substances, polymers and macromolecules. This paper concentrates on the examination of the anomalous magnetic properties of some nucleic acids and synthetic polymers. The nature of these effects is still unclear, and even if they are not related to the antiferromagnetism (as is assumed by the authors, cf.Ref.2), an analysis of the properties of "polymer-type" ferro- and antiferromagnetics is still of significance. The approximate method used to determine

Card 1/2

86905

Theory of Ferro- and Antiferromagnetism

S/056/60/039/005/022/051
B006/B077

the magnetic quantities in relation to size and shape of the specimens (small particles, films, polymer chains, etc.) is based on a self-consistent generalization of the spin wave theory using the usual model of localized spins with exchange interaction. Although this model is far from representing the real conditions the results obtained are essentially of general validity, that is, independent of the model and can be regarded as semi-phenomenological. The problem is also examined as to when and to what extent the assumption of small particles and polymer chains forming a "paramagnetic fluid" is valid. The magnetic properties of such a fluid are studied. M. I. Kaganov, N. N. Bogolyubov, S. V. Tyablikov, Pu Fu-cho, and L. A. Blyumenfel'd are mentioned. There are 30 references: 9 Soviet, 15 US, 2 German, and 4 British.

ASSOCIATION: Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Institute of Radio Physics of the Gor'kiy State University)

SUBMITTED: May 26, 1960

AUTHORS: Ginzburg, V. L., Corresponding Member, AS USSR, Fayn, V. M.

S/020/60/131/04/019/073
B013/B007

TITLE: Possible Anomalies of the Magnetic Properties of Macromolecules

PERIODICAL: Doklady Akademii nauk SSSR, 1960, Vol 131, Nr 4, pp 785-788 (USSR)

TEXT: Strong lines of electron paramagnetic resonance and anomalous magnetic properties have recently been detected in a number of macromolecules (polymers). In this connection it is essential that the initial links of the chain and the short chains (monomers) are diamagnetic or ferromagnetic. Consequently, this means a transition (with elongation of the chain) from a diamagnetic state into a paramagnetic or ferromagnetic one. The authors give an explanation of this hitherto unexplained effect. They assume that the finite, but not too short and not too long chain of monomers is antiferromagnetic. The electrons under consideration then form two antiparallel sublattices. The antiferromagnetic level is the lowest level of the whole system. It is further assumed that the antiferromagnetic level is the lowest level in a chain of monovalent atoms with the exchange interaction $H_{ex} = -\frac{1}{2}\sum_{lm} 2 J_{lm}\vec{S}_l\vec{S}_m$ at J_{lm}. Here, $\vec{S}_l$ denotes the spin operator in $\hbar$ units. When the chain is stretched, antiferromagnetism may

Card 1/3

Possible Anomalies of the Magnetic Properties of Macromolecules

S/020/60/131/04/019/073
B013/B007

occur already with weak anisotropy fields. Approximation of the spin waves with the magnetic moment $\pm\mu$ is convenient for the lowest excited levels of an antiferromagnetic body (as well as in the case of ferromagnetic bodies). The excitation energy of the antiferromagnetic body is equal to the totality of such independent waves with the energies $n_k^{\pm} \varepsilon_k^{\pm}$, $n_k^{\pm} = 1,2,\dots$, where $\varepsilon_k^{\pm} = \varepsilon_k \pm \mu H$; $\varepsilon_k = \sqrt{(\mu H_A + 2J)^2 - 4J^2\cos^2 a\, k}$ holds. Here, $\mu = ge\hbar/2mc$ denotes the magnetic moment of excitation, H - the outer magnetic field, a - the lattice constant, $k = \pi l/Na$ - the wave vector. The levels $\varepsilon_k^{\pm}$ are lowered with increasing N, and if there is no H-field they tend to zero with $N \to \infty$ and $H_A \to 0$. In the unidimensional case a sufficiently long antiferromagnetic chain is unstable. The magnetic susceptibility χ of an antiferromagnetic body is determined by the lowest levels, which fact holds also for a two-dimensional system. For the estimation of χ for a chain the lowest level will suffice. In converting the susceptibility of the chains to the paramagnetic case it is possible to assume the "depairing" of all outer electrons in the monomers. In the case of polycrystals absorption occurs

Card 2/3

Possible Anomalies of the Magnetic Properties of Macromolecules

S/020/60/131/04/019/073
B013/B007

at a certain frequency ν not only with a certain value of H but in a wide frequency range. The lateral links which "cement" the chains into the three-dimensional body, play a stabilizing part. Of special importance is the determination of the temperature dependence of the magnetic moment of the samples. It is possible that the spin waves play an important part also in biological processes. The authors thank L. A. Blyumenfel'd and V. A. Benderskiy for experimental data and a discussion. There are 1 figure and 16 references, 7 of which are Soviet.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences of the USSR) Nauchno-issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom gosudarstvennom universitete imeni N. I. Lobachevskogo (Radiophysical Scientific Research Institute of Gor'kiy State University imeni N. I. Lobachevskiy)

SUBMITTED: January 3, 1960

Card 3/3

28766

9,2574 &c 1144

S/056/61/041/003/019/020
B113/B102

AUTHORS: Fayn, V. M., Khanin, Ya. I., Yashchin, E. G.

TITLE: Nonlinear properties of three-level systems

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 3(9), 1961, 986-988

TEXT: A reaction (e.g. polarization P) of a three-level system to two monochromatic signals may serve as characteristics of the nonlinear properties of this system. E_1, E_2, E_3 are assumed to be three levels of a quantum system. An external field $F = E_{13} \cdot \cos\Omega_{31} t + E_{23} \cdot \cos\Omega_{32} t$ (1) is assumed to act upon this system; the frequencies are $\Omega_{31} \approx (E_3 - E_1)/\hbar$ and $\Omega_{32} \approx (E_3 - E_2)/\hbar$. The equation for the density matrix ρ_{mn} is used in order to determine the field-induced polarization of the system. If in the solution of this equation only the resonance terms with the frequencies Ω_{32}, Ω_{31}, and $\Omega_{31} - \Omega_{32}$ are used and if one goes over to a system of corresponding algebraic equations, then the equation

Card 1/3

28766

Nonlinear properties of three-level... S/056/61/041/003/019/020
B113/B102

$$P = \bar{\rho}_{31}\mu_{13}e^{-i\Omega_{31}t} + \bar{\rho}_{32}\mu_{23}e^{-i\Omega_{32}t} + \bar{\rho}_{21}\mu_{12}e^{-i(\Omega_{31}-\Omega_{32})t} + \text{c.c.} \qquad (4)$$

is obtained where

$$\bar{\rho}_{31} = 2i\gamma_{31}\Delta^{-1}\{D_{13}^{(0)}[4(\tau_2^{-1} + \gamma_{23}^2\tau_1) + \tau_2\gamma_{13}^2] - D_{23}^{(0)}(2\tau_1 + \tau_2)\gamma_{23}^2\},$$

$$\bar{\rho}_{32} = 2i\gamma_{32}\Delta^{-1}\{D_{23}^{(0)}[4(\tau_2^{-1} + \gamma_{13}^2\tau_1) + \tau_2\gamma_{23}^2] - D_{13}^{(0)}(2\tau_1 + \tau_2)\gamma_{13}^2\},$$

$$\bar{\rho}_{21} = \tfrac{1}{2}i\tau_2\gamma_{13}\gamma_{23}(\bar{\rho}_{32}/\gamma_{23} + \bar{\rho}_{31}/\gamma_{13}) = -2\gamma_{13}\gamma_{23}\tau_2\Delta^{-1}\{D_{13}^{(0)}[2(\tau_2^{-1} + \tau_1\gamma_{23}^2) - \tau_1\gamma_{13}^2] + D_{23}^{(0)}[2(\tau_2^{-1} + \gamma_{13}^2\tau_1) - \tau_1\gamma_{23}^2]\};$$

$$\Delta = [4(\tau_2^{-1} + \gamma_{23}^2\tau_1) + \tau_2\gamma_{13}^2][4(\tau_2^{-1} + \gamma_{13}^2\tau_1) + \tau_2\gamma_{23}^2] - (2\tau_1 + \tau_2)^2\gamma_{13}^2\gamma_{23}^2;$$

$$\gamma_{13} = \mu_{13}E_{13}/\hbar = \gamma_{31}, \qquad \gamma_{23} = \mu_{23}E_{23}/\hbar = \gamma_{32};$$

holds if $\Omega_{31} = (E_3 - E_1)/\hbar$ and $\Omega_{32} = (E_3 - E_2)/\hbar$ and $D_{13}^{(o)}$ and $D_{23}^{(o)}$ are equilibrium differences of the level population, τ_1 and τ_2 are the longitudinal and transverse relaxation times, respectively, and μ_{ml} is the matrix of the dipole moments. (4) indicates that the reaction of the system to two monochromatic signals contains a term with the combined frequency $\Omega_{12} = \Omega_{13} - \Omega_{23}$ which results from the nonlinearity of

Card 2/3

28766

Nonlinear properties of three-level... S/056/61/041/003/019/020
B113/B102

the system. There are 8 references: 2 Soviet and 6 non-Soviet. The three most recent references to English-language publications read as follows: N. Bloembergen, S. Shapiro. Phys. Rev., 116, 1453, 1959; P. P. Sorokin, M. J. Stevenson, Phys. Rev. Lett., 5, 557, 1960; A. Javan, W. R. Bennett, Jr., A. R. Herriott. Phys. Rev. Lett., 6, 106, 1961.

ASSOCIATION: Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Radiophysics Institute of Gor'kiy State University)

SUBMITTED: June 26, 1961

4

Card 3/3

26702
S/056/61/041/005/017/038
B102/B108

9.2576 (1532, 1538)

AUTHORS: Fayn, V. M., Khanin, Ya. I.

TITLE: Self-excitation conditions of a laser

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v.41, no. 5(11), 1961, 1498-1502

TEXT: The authors investigated theoretically the self-excitation conditions of a molecular generator with a cavity whose dimensions are considerably greater than the wave length of the generated waves. The cavity is assumed to be completely filled with weakly interacting molecules with two energy levels. The state of the system is characterized by the density of the energy spin s(r,t) whose components satisfy the conditions

$$\begin{aligned}
&\dot{s}_1 + \omega_0 s_2 + \frac{1}{T_2} s_1 + \frac{1}{\hbar}\sum_\lambda A_\lambda(r)\, e_2 s_3 q_\lambda = 0,\\
&\dot{s}_2 - \omega_0 s_1 + \frac{1}{T_2} s_2 - \frac{1}{\hbar}\sum_\lambda A_\lambda(r)\, e_1 s_3 q_\lambda = 0,\\
&\dot{s}_3 = \frac{1}{T_1}(s_3^0 - s_3) - \frac{1}{\hbar}\sum_\lambda A_\lambda(r)\,(e_1 s_2 - e_2 s_1)\, q_\lambda;\\
&\ddot{q}_\lambda + \frac{\omega_\lambda}{Q_\lambda}\dot{q}_\lambda + \omega_\lambda^2 q_\lambda = \int_{V_0} A_\lambda(r)\,(e_1 s_1 + e_2 s_2)\, dV.
\end{aligned} \qquad (1)$$

Self-excitation conditions of a laser

ω_0 is the molecular transition frequency, ω_λ the natural frequency of the cavity, Q_λ the quality factors corresponding to these frequencies, T_1 and T_2 the Bloch relaxation times, $\vec{e}_1$ and $\vec{e}_2$ molecular constants, which are functions of the matrix elements of the dipole moment: $\frac{1}{c}\frac{d\hat{\vec{\mu}}}{dt} = \vec{e}_1 r_1 + \vec{e}_2 r_2$; $\hat{\vec{\mu}}$ is the operator of the molecular dipole moment, r_1 and r_2 are the spin matrices. $\vec{e}_1 + i\vec{e}_2 = (2i\omega_0/c)\vec{\mu}_{21}$, $\vec{e}_1 - i\vec{e}_2 = (-2i\omega_0/c)\vec{\mu}_{12}$. When the vector potential of the electromagnetic field is expanded into eigenfunctions of a cavity with ideally conducting walls: $\vec{A}(\vec{r},t) = \sum_\lambda \vec{A}_\lambda(\vec{r})q_\lambda(t)$, $\int_{V_\pi} A_\lambda^2 dV = 4\pi c^2$, and with $\vec{A}_\lambda\vec{e}_1/\hbar = \alpha_{1\lambda}$, $\vec{A}_\lambda\vec{e}_2 = \alpha_{2\lambda}$, $\alpha_{2\lambda} - i\alpha_{1\lambda} = \alpha_\lambda$,

$s_1 + is_2 = P_1$, $s_1 - is_2 = P_2$, the system (1) can be represented by

$$\dot{P}_1 + (T_2^{-1} - i\omega_0) P_1 + \sum_\lambda \alpha_\lambda q_\lambda s_3 = 0, \quad (7a)$$

$$\dot{P}_2 + (T_2^{-1} + i\omega_0) P_2 + \sum_\lambda \alpha_\lambda^* q_\lambda s_3 = 0, \quad (7б)$$

$$\dot{s}_3 = \frac{1}{T_1}(s_3^0 - s_3) + \frac{1}{2}\sum_\lambda (P_1\alpha_\lambda^* + P_2\alpha_\lambda) q_\lambda, \quad (7в)$$

$$\ddot{q}_\lambda + \frac{\omega_\lambda}{Q_\lambda}\dot{q}_\lambda + \omega_\lambda^2 q_\lambda = -\frac{i\hbar}{2}\int_{V_\text{п}} (P_1\alpha_\lambda^* - P_2\alpha_\lambda)\, dV. \quad (7г)$$

The $P_{1,2}$ are expanded according to

$$P_1(\mathbf{r}, t) = \sum_\lambda \alpha_\lambda(\mathbf{r}) P_{1\lambda}(t), \qquad P_2(\mathbf{r}, t) = \sum_\lambda \alpha_\lambda^*(\mathbf{r}) P_{2\lambda}(t). \quad (8).$$

The self-excitation conditions can be determined from an analysis of the system (7). At the initial moment, $P_{1\lambda}$, $P_{2\lambda}$, and q_λ are assumed to be near zero, and $s_3 = s_3^o$. It is assumed that the small perturbations $P^o_{1\lambda}e^{i\xi_\lambda t}$, $P^o_{2\lambda}e^{i\xi_\lambda t}$, $q^o_\lambda e^{i\xi_\lambda t}$ exist, with $\xi_\lambda = \Omega_\lambda + i\delta_\lambda$. Eqs. (7) with (8) lead to a system of homogeneous algebraic equations which have non-trivial solutions when the determinant

$$\xi_\lambda^4 - i\xi_\lambda^3(\omega_\lambda/Q_\lambda + 2/T_2) - \xi^2(\omega_\lambda^2 + \omega_0^2 + T_2^{-2} + 2\omega_\lambda/Q_\lambda T_2) + i\xi_\lambda\omega_\lambda[2\omega_\lambda/T_2 + (\omega_0^2 + T_2^{-2})/Q_\lambda] + \omega_\lambda^2(\omega_0^2 + T_2^{-2}) + \hbar a^2\omega_0 s_3^0 = 0. \quad (11)$$

vanishes. In the case $|\delta_\lambda| \ll \Omega_\lambda$ and neglecting the terms with δ_λ^2, δ_λ^3 and δ_λ^4 two real equations can be set up for Ω_λ and δ_λ. Here only the solutions of (7) which are increasing with time are of interest ($s_3^o > s_{3cr}$). For $\delta_\lambda = 0$ holds

$$\Omega^2_{\lambda cr} = \frac{\omega_\lambda(\omega_o^2 T_2 + T_2^{-1} + 2Q_\lambda\omega_\lambda)}{\omega_\lambda T_2 + 2Q_\lambda} \quad (12)$$

Card 4/6

26702
S/056/61/041/005/017/038
B102/B108

Self-excitation conditions of a laser

$$s^{o}_{3cr} = \frac{\omega_\lambda \left[(\omega_o^2 - \Omega^2_{\lambda cr} + T_2^{-2})^2 + 4T_2^{-2}\Omega^2_{\lambda cr}\right]}{2Q_\lambda T_2^{-1}\omega_o \hbar a^2} \quad (13),$$

from which the boundaries of the region of self-excitation can be estimated: $(s^o_{3cr})_{min} \approx 2\omega_o^2/\hbar a^2 Q_\lambda T_2$, $(T_2^{-2} \ll \omega_o^2$, $\omega_\lambda = \Omega_\lambda = \omega_o)$. $\Omega^2_\lambda = \omega_o^2 - T_2^{-2}$. $N_{min} = 2(s^o_{3cr})_{min} = \hbar/4\pi|\vec{\mu}_{12}|^2 Q_\lambda T_2$. These conditions agree with those found by N. G. Basov and A. M. Prokhorov (ZhETF, 30, 560, 1956). If the resonator walls are ideally conducting, the relations

$$\int\limits_{V_n+V_{CK}} \sum_\mu A_\lambda A_\mu \, dV = \int\limits_{V_n} \sum_\mu A_\lambda A_\mu \, dV + \int\limits_{V_{CK}} \sum_\mu A_\lambda A_\mu \, dV, \quad (17)$$

$$\int\limits_{V_n} \sum_\mu A_\lambda A_\mu \, dV \equiv \int\limits_{V_n} A_\lambda^2 \, dV \gg \int\limits_{V_{CK}} \sum_\mu A_\lambda A_\mu \, dV. \quad (18)$$

$$\sum_\mu \int\limits_{V_{CK}} A_\lambda A_\mu \, dV \leqslant \sum_\mu \int\limits_{V_{CK}} (\max A_\mu)^2 \, dV = n (\max A_\mu)^2 V_{CK},$$

Card 5/6

$$\int_{V_n} A_\lambda^2 dV \gg n\,(\max A_\lambda)^2 V_{ск}. \quad (19)$$

hold true; $V_П$ is the cavity volume and $V_{ск}$ the volume of the skin layer, n is the total number of natural frequencies of the cavity. The approximation derived is applicable when $Q \gg n$. This inequality is fulfilled up to optical frequencies (lasers). There are 8 references: 4 Soviet and 4 non-Soviet. The four references to English-language publications read as follows: H. Lyons. Astronautics, 5, 39, 1960; R. J. Collins, D. F. Nelson, A. L. Schawlow, W. Bond, C. G. B. Garrett, W. Kaiser.Phys. Rev. Let., 5, 303, 1960; A. L. Schawlow, C. H. Townes, Phys. Rev., 112, 1940, 1958; A. G. Fox, T. Li. PIRE, 48, 1904, 1960.

ASSOCIATION: Gor'kovskiy radiofizicheskiy institut (Gor'kiy Institute of Radiophysics)

SUBMITTED: April 22, 1961

26704
S/056/61/041/005/019/038
B102/B108

24,7900

AUTHORS: Genkin, V. N., Fayn, V. M.

TITLE: The width of antiferromagnetic resonance lines

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 5(11), 1961, 1522-1526

TEXT: The authors developed a method to estimate the antiferromagnetic resonance line widths or the corresponding relaxation times due to the interaction between the homogeneous magnetization precession and the spin waves. A. I. Akhiyezer et al. (ZhETF, 36, 216, 1959; UFN, 72, 3, 1960) have studied this interaction in ferromagnetics, for which the line width was found to be very small since exchange interaction does not affect the homogeneous precession. In the case of antiferromagnetics this interaction is most effective and the lines become wider. The Hamiltonian of the spin system is

$$\mathcal{H} = 2J \sum_{\langle lm \rangle} S_l S_m + g\beta H_A \left(\sum_l S_l^z - \sum_m S_m^z \right) \qquad (1),$$

Card 1/8

26704
S/056/61/041/005/019/038
B102/B108

The width of antiferromagnetic ...

with $\underline{S}_l$ and $\underline{S}_m$ being the spin operators of the first and the second sublattice, ⟨lm⟩ indicates summation over the nearest neighbors, the exchange integral J>0 and H_A is the effective field of anisotropy. Introducing the operators of spin deviation and neglecting terms of an order higher than the third,

$$S_l^+ = (2S)^{1/2}(1 - a_l^* a_l/4S)\, a_l, \quad S_l^- = (2S)^{1/2} a_l^* (1 - a_l^* a_l/4S), \quad (2)$$
$$S_l^z = S - a_l^* a_l, \quad S_m^+ = (2S)^{1/2} b_m^* (1 - b_m^* b_m/4S),$$
$$S_m^- = (2S)^{1/2}(1 - b_m^* b_m/4S)\, b_m, \quad S_m^z = -S + b_m^* b_m, \quad S_{lm}^{\pm} = S_{lm}^x \pm iS_{lm}^y$$

is found. With these operators, the Hamiltonian (1) may be separated into sums of second-order and fourth-order terms of a and b. The second-order terms are diagonalized and represent the unperturbed spin-wave Hamiltonian. The fourth-order terms represent the spin-wave interaction energy

$$\mathcal{H}' = -2J \sum_{\langle lm \rangle} \left\{ \tfrac{1}{4}(a_l^* a_l a_l b_m + a_l b_m^* b_m b_m + b_m a_l^* a_l^* a_l + b_m^* b_m^* b_m a_l^*) + a_l^* a_l b_m^* b_m \right\}.$$ The

Card 2/4

operators a and b are given in Fourier representation and with $a_k = \alpha_k \mathrm{ch}\, \Theta_k - \beta_k^* \mathrm{sh}\, \Theta_k$, $b_k = -\alpha_k^* \mathrm{sh}\, \Theta_k + \beta_k \mathrm{ch}\, \Theta_k$. $\mathrm{th}\, 2\Theta_k = \gamma_k/D$; $D = 1 + g\beta H_A/zJS$, where 2z is the number of the nearest spins. The interaction Hamiltonian can be represented as

$$\mathcal{H}' = \frac{Jz}{N} \sum_{1,2,3,4} \{\Phi_{1(23)4}\alpha_1\dot{\alpha}_2\dot{\alpha}_3\alpha_4 + \Psi_{1(23)4}\beta_1\dot{\beta}_2\dot{\beta}_3\beta_4 + \lambda_{1234}\dot{\alpha}_1\alpha_2\dot{\beta}_3\beta_4 - \Phi_{1234}\dot{\alpha}_1\alpha_2\alpha_3\dot{\beta}_4 - \Psi_{1234}\dot{\beta}_1\beta_2\beta_3\alpha_4\}\, \Delta(k_1 - k_2 - k_3 + k_4). \quad (4)$$

from which the terms of the type $\alpha_1\alpha_2\beta_3\beta_4$ are eliminated. The Hamiltonian (4) describes the spin-wave interaction processes. The operators α_o and α_o^* are used to investigate the relaxation of the uniform precession of the magnetization. It is assumed that the spin waves are in thermodynamical equilibrium at the temperature T. The probability of processes in which the number of spin waves is changed is determined. For low temperatures ($kT < \varepsilon_o$), the main contribution to the line width is due to processes of

Card 3/6

the type

$$W(n_1, n_2, n_3', n_4' \to n_1+1, n_2-1, n_3'+1, n_4'-1) = \frac{2\pi}{\hbar}\frac{\varepsilon_{06}^2}{4N^2}|\lambda_{1234}+\lambda_{2141}|^2 \times \times \Delta(\mathbf{k}_1+\mathbf{k}_4-\mathbf{k}_2-\mathbf{k}_3)\,\delta(\varepsilon_1-\varepsilon_2-\varepsilon_3'-\varepsilon_4')(n_1+1)\,n_2\,(n_3'+1)\,n_4' \qquad (7)$$

and the magnetization precession relaxation is given by

$$\dot{n}_0 = \sum_{234}[W(n_0, n_2, n_3', n_4' \to n_0+1, n_2-1, n_3'-1, n_4'-1) - - W(n_0, n_2, n_3', n_4' \to n_0-1, n_2+1, n_3'-1, n_4'+1)] + + \sum_{134}[W(n_1-1, n_0, n_3'-1, n_4'+1 \to n_1, n_0+1, n_3', n_4') - - W(n_1, n_0, n_3', n_4' \to n_1+1, n_0-1, n_3'+1, n_4'-1)]. \qquad (9);$$

$n_{k\neq 0} = \bar{n}_k = 1/(e^{\varepsilon_k/kT} - 1)$. $\varepsilon_{0\alpha} = 2Jz$, the primed quantities refer to the spin waves described by the β operators; n_k and n_k' are the mean numbers of the α- and β spin waves for states with the momentum $\vec{k}$; ε_k and ε_k' are the energies of magnons with momentum $\vec{k}$. Eq. (9) can be written as $\dot{n}_0 = -\lambda(n_0 - \bar{n}_0)$ where λ^{-1} is the mean precession relaxation time:

$$\lambda = \frac{\pi}{\hbar}\frac{\varepsilon_{0\alpha}^2}{N^2}\sum_{234}|\lambda_{0234} + \lambda_{2043}|^2 \Delta(\mathbf{k}_4 - \mathbf{k}_2 - \mathbf{k}_3)\,\delta(\varepsilon_0 - \varepsilon_2 + \varepsilon_3' - \varepsilon_4') \times \times (n_4' - n_2 n_4' + n_2 n_3' + n_3' n_4'). \quad (10)$$

or, for $\vec{k}\vec{l} \ll 1$

$$\lambda = \frac{27}{\hbar (2\pi)^3 \varepsilon_{0\alpha}^4}\int \frac{(\varepsilon_2^2 - \varepsilon_0^2)^{1/2}(\varepsilon_3^2 - \varepsilon_0^2)^{1/2}\cos^2\theta\, d\theta \sin\theta}{\varepsilon_0 \varepsilon_{3+2}} \times \times e^{-\varepsilon_3/kT}\delta(\varepsilon_0 - \varepsilon_2 + \varepsilon_3 - \varepsilon_{3+2})\, d\varepsilon_3 d\varepsilon_2. \quad (12)$$

with $\varepsilon_{3+2} = \varepsilon_{\vec{k}_3 + \vec{k}_2}$ and $D^2 \approx 1$. With $\varepsilon_{2+3} < \varepsilon_3$ and $\pi/2 < \theta < \pi$ the authors find

Card 5/8

26704
S/056/61/041/005/019/038
B102/B108

$$\frac{\lambda}{\omega_0} = h_A^2 \frac{e^{-x_0}}{x_0^6}(16x_0^4 + 30x_0^3 + 46x_0^2 + 54x_0 + 37),$$

$x_0 = (\varepsilon_0/kT)$, $h_A = g\beta H_A/zJS = H_A/H_E$. H_E is the intensity of the field of the exchange forces, and $\omega_0 = \varepsilon_0/\hbar$ is the antiferromagnetic resonance frequency. For MnF_2 $\lambda = 160$ G at $T = 6^oK$ and $\lambda = 12$ G at $T = 4^oK$. This estimation shows that already at such low temperatures the lines are considerably broadened. There are 6 references: 1 Soviet and 5 non-Soviet. The four references to English-language publications read as follows: A. M. Clogston et al. J. Phys. Chem. Solids, 1, 129, 1956; J. Van Kranendonk, J. H. Van Vleck, Rev. Mod. Phys., 30, 1, 1958. T. Holstein, H. Primakoff, Phys. Rev., 58, 1908, 1940. F. M. Johnson, A. N. Nethercot. Phys. Rev. 114, 705, 1959.

ASSOCIATION: Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Radiophysics Institute of Gor'kiy State University)

FAYN, V.M.; KHANIN, Ya.I.; YASHCHIN, E.G.

Interaction of electromagnetic oscillations in three-level systems. Izv. vys. ucheb. zav.; radiofiz. 5 no.4:697-713 '62. (MIRA 16:7)

1. Nauchno-issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete.

(Radio waves) (Radio)

45624

S/141/62/005/006/008/023
E192/E382

24.7000

AUTHORS: Genkin, V.N. and Fayn, V.M.

TITLE: On the theory of ferro- and antiferromagnetic resonance

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, v. 5, no. 6, 1962, 1115 - 1122

TEXT: Experiments on ferromagnetic (or antiferromagnetic) resonance usually determine the average values of the components of the magnetic moment. On the other hand, when theoretically investigating the relaxation processes in these systems, the equilibrium equations are used which are based on the average number of magnones n_o and n_k. An attempt is made, therefore, to determine theoretically the mean values of the transverse components of the magnetic moment and, for this purpose, the kinetic equations for the density matrix $\rho_{m\alpha;n\alpha}$ are employed. The system is dissipative with regard to the subscript 'α' and, in general, nondiagonal with regard to the subscript 'm, n'. The Hamiltonian of such a system, consisting of interacting dynamic

Card 1/ 4

S/141/62/005/006/008/023
E192/E382

On the theory of ....

and dissipative sub-systems, is in the form:

$$\hat{H} = \hbar E + \hbar\hat{F} + \hbar\hat{V} \quad (1)$$

where $\hbar\hat{E} = \hbar\hat{E}_o + \hbar\hat{W}(t)$ is the Hamiltonian of the dynamic sub-system which is subjected to the action of an external field $\hbar\hat{W}(t)$, $\hbar\hat{F}$ is the Hamiltonian of the dissipative sub-system and $\hbar\hat{V}$ is the interaction energy. The kinetic equation for the system is in the form:

$$\frac{\partial\hat{\rho}}{\partial t} + i\left[\hat{E}_o + \hat{W} + \hat{N}, \hat{\rho}\right] = R(\hat{\rho}) \quad (2)$$

where ρ is the density matrix which is diagonal with respect to the subscripts of the dissipative sub-system and:

$$N_{m\alpha;n\alpha} = -\sum_{k,\alpha'} \frac{V_{m\alpha;k\alpha'} V_{k\alpha';n\alpha}}{E_k - E_n + F_{\alpha'} - F_\alpha} \Delta(\omega_{nm}) \quad (3)$$

Card 2/4

along the axis of anisotropy z while an alternating magnetic field is polarized in the plane x, y. The antiferromagnetic resonance is also investigated by using the same equation. It is found that in the latter case, unlike in ferromagnetics, the exchange interaction in the presence of anisotropy plays an essential part in the resonance.

ASSOCIATION: Nauchno-issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Scientific Research Radiophysics Institute of Gor'kiy University)

SUBMITTED: May 18, 1962

34012
S/056/62/042/001/030/048
B102/B108

24.2200 (1144,1147,1164)

AUTHORS: Ginzburg, V. L., Fayn, V. M.

TITLE: Magnetic properties of paramagnetic "fluids" of the type of molecular chains

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 1, 1962, 183 - 190

TEXT: Continuing their own studies (DAN SSSR, 131, 785, 1960; ZhETF, 39, 1323, 1960) the authors investigate the dependence of magnetic susceptibility χ on the length of a certain type of polymer chains. It is shown that a chain of spins may be regarded as forming a paramagnetic fluid with an abnormally low or zero Curie temperature. A polymer is considered which consists of N monomeric links, each link having an even number of outer electrons with a singlet ground state (energy E_1). In the simplest case the first excited state is a triplet with E_3, $E_3-E \sim J_0$, J_0 being the exchange interaction energy of the monomer. For $J_0 \gg kT$, the monomer will be diamagnetic. If the system is in the antiferromagnetic

Card 1/4

APPROVED FOR RELEASE: 08/22/2000 CIA-RDP86-00513R000412520005-2"

S/056/62/042/001/030/048
B102/B108

Magnetic properties of paramagnetic...

state, and if the chain is not too long, $\chi \sim (\mu^2/kT)\exp(-\xi J/kTN)$, $\xi \sim 1$. It is further assumed that $\Delta E_{min} \sim J/N$, ΔE_{min} being the distance between the ground state and the lowest excited state of the system. For a chain of 4, 6, 8, or 10 spins ΔE_{min} = const$\cdot$J/N for $J > 0$ and for spins 0 or 1. If the exchange Hamiltonian reads $\mathcal{H}_{ex} = 2J\sum_{l=1}^{N}(\vec{s}_l\vec{s}_{l+1} - \frac{1}{4})$, $s_{lz} = \pm\frac{1}{2}$; the mean magnetic moment in a field $H \parallel z$ is given by

$$M_z = \frac{\sum_{n,S_z} \mu S_z \exp\{-(E(n,S_z) - \mu S_z H)/kT\}}{\sum_{n,S_z} \exp\{-(E(n,S_z) - \mu S_z H)/kT\}}, \qquad \mu = \frac{e\hbar}{mc}. \qquad (6)$$

and for $H \to 0$,

$$\chi = \frac{dM_z}{dH} = \frac{\mu^2}{kT}\sum_{S_z} S_z^2 g_{S_z} \Big/ \sum_{S_z} g_{S_z}, \qquad g_{S_z} = \sum_n \exp\{-E(n,S_z)/kT\}. \qquad (7)$$

;

Card 2/4

Magnetic properties of paramagnetic...

$S_z = \sum s_{lz}$; s_l is the spin operator in terms of $\hbar$. $\chi(T)/\chi_0 = 2J\chi(T)/\mu^2 N$ was calculated numerically and the curves were drawn for several N, $\alpha = 0$ and $\alpha = 1$ (Ising model). It can be seen that for $N \ll J/kT$, χ is very small and increases exponentially with N, reaching $\sim \mu^2 N/J$ when $N \sim J/kT$. The calculations were carried out at the NIRFI GGU under the supervision of G. M. Zhislin. For $N \to \infty$ and $\alpha = 1$, $\chi(T,H=0) = (\mu^2 N/4kT)\exp(-J/kT)$. In this case $\chi \sim \mu^2 N/J$ only at $\sim kT$. In the following the relations between the properties of simple spin chains and the behavior of real molecular chains are discussed and some approximate results for large N (infinite chains) are given. For $\alpha \ll 1$,

$$\chi(0) = (\mu^2 N/18J)\left(1 - \tfrac{1}{3}\alpha\right), \quad \chi(T \gg J/k) = \mu^2 N/4kT. \qquad (11)$$

for $(1-\alpha) \ll 1$,

$$\chi(0) = \mu^2 (1-\alpha)^2 N/4J, \quad \chi(T \gg J/k) = \mu^2 N/4kT. \qquad (12)$$

It is shown that for a chaintype paramagnetic fluid with antiferromagnetic interaction $\chi \neq 0$ at $T = 0$; with ferromagnetic interaction and $\alpha = 1$, $J < 0$; $\chi(0) = \infty$. G. A. Semenov is thanked for help. There are 5 figures

Card 3/4

S/056/62/042/001/030/048
B102/B108

Magnetic properties of paramagnetic...

and 13 references: 6 Soviet and 7 non-Soviet. The four most recent references to English-language publications read as follows: T. W. Ruijgrok. S. Rodriguez. Phys. Rev. 119, 596, 1960; C. Domb. Adv. Phys. 9, 149, 1960; D. Paul Phys. Rev. 118, 92, 1960; 120, 463, 1960; L. F. Mattheiss. Phys. Rev. 123, 1209, 1961.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR). Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Institute of Radiophysics of Gor'kiy State University)

SUBMITTED: July 4, 1961

Card 4/4

37140

S/056/62/042/004/025/037
B108/B102

24.4400

AUTHOR: Fayn, V. M.

TITLE: Quantum theory of relaxation processes

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 4, 1962, 1075 - 1083

TEXT: Relaxation of a system consisting of a dynamic subsystem with a finite number of degrees of freedom and a discrete spectrum, and of a dissipative subsystem with an infinite number of degrees of freedom and a continuous spectrum is considered. The master equation, i. e. the quantum kinetic equation for the density matrix $\rho_{m\alpha;n\alpha}$ (nondiagonal with respect to the discrete indices m, n; diagonal with respect to the continuous indices α) of the entire system is derived. The energy $\hat{W}(t)$ of interaction with external forces is assumed to be sufficiently small.

Card 1/3

The master equation for the density matrix is then

$$\frac{\partial \rho_{m\alpha;\, n\alpha}}{\partial t} + \frac{i}{\hbar}[\hat{W}(t), \hat{\rho}]_{m\alpha;\, n\alpha} =$$

$$= \frac{\pi}{\hbar} \sum_{k,\, l,\, \alpha'} \{V_{m\alpha;\, k\alpha'} V_{l\alpha';\, n\alpha} \rho_{k\alpha';\, l\alpha'} [\delta(E_m + E_\alpha - E_k - E_{\alpha'}) +$$

$$+ \delta(E_l + E_{\alpha'} - E_n - E_\alpha)] \delta_{\omega_{mk} + \omega_{ln};\, 0} -$$

$$- V_{m\alpha;\, k\alpha'} V_{k\alpha';\, l\alpha} \rho_{l\alpha;\, n\alpha} \delta(E_m + E_\alpha - E_k - E_{\alpha'}) \delta_{\omega_{ml};\, 0} -$$

$$- V_{k\alpha;\, l\alpha'} V_{l\alpha';\, n\alpha} \rho_{m\alpha;\, k\alpha} \delta(E_l + E_{\alpha'} - E_n - E_\alpha) \delta_{\omega_{kn};\, 0}\}. \qquad (17)$$

$\hat{V}$ is the interaction energy between the dynamic and the dissipative subsystems. With the aid of this general equation the equations established previously by L. Van Hove (Physica, 23, 441, 1957), R. K. Wangsness and F. Bloch (Phys. Rev., 89, 728, 1952) are derived as particular cases. The applicability of various quantum kinetic equations to quantum radiophysics is briefly discussed. There are 17 references: 4 Soviet and 13 non-Soviet. The four most recent English-language references read as follows: A. Sher,

S/056/62/042/004/025/037
B108/B102

Quantum theory of ...

H. Primakoff. Phys. Rev., 119, 178, 1960; M. Kac. Probability and Related Topics in Physical Sciences, Interscience Publishers, London, 1959; F. Bloch. Phys. Rev., 102, 104, 1955; 105, 1206, 1957.

ASSOCIATION: Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Institute of Radiophysics of Gor'kiy State University)

SUBMITTED: October 23, 1961

Card 3/3

L 10009-63 BDS/EWT(1)--AFFTC/AFWL/ASD/ESD-3--IJP(C)/WG

ACCESSION NR: AP3000147 S/0141/63/006/002/0207/0241

57
56

AUTHOR: Fayn, V. M.

TITLE: Induced and spontaneous radiations (a review)

SOURCE: Izvestiya vysshikh uchebnykh zavedeniy radiofizika, v. 6, no. 2, 1963, 207-241

TOPIC TAGS: quantum radiophysics, induced radiation, spontaneous radiation

ABSTRACT: Induced and spontaneous radiations that play an important role in radio-physics are reviewed on the basis of 23 Russian, German, and American publications most of them recent. Special attention is paid to the connection between the classical and quantum relations, to phase relations, directional diagram, zero fluctuations, etc. The first section deals with the concept of both types of radiation and with the Einstein's theory. The second section presents the results of classical treatment of the radiations. The third section presents the quantum theory as applied to these radiations; at variance with ordinary transition-probability approach, the quantum equations of motion are used. The fourth section contains detailed comparisons with the classical

Card 1/2

L 10009-63
ACCESSION NR: AP3000147

relations, phase relations, etc. In the fifth section the problem of induced and spontaneous radiations in a system whose levels form a continuous spectrum is considered. Section six briefly outlines the theory of both radiations in the free space. The last, seventh, section covers (1) fundamental equations, (2) free motion (no external field), (3) induced radiation in a real resonator, (4) spontaneous radiation in a resonator, and (5) induced and spontaneous radiations in masers. Orig. art. has: 97 equations.

ASSOCIATION: Nauchno-issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Scientific-Research Radiophysics Institute, Gor'kiy University)

SUBMITTED: 27Nov62 DATE ACQ: 12Jun63 ENCL: 00

SUB CODE: PH NR REF SOV: 017 OTHER: 006

Card 2/2

L 13640-63 EWT(1)/BDS AFFTC/ASD

ACCESSION NR: AP3003121 S/0056/63/044/006/1915/1919

52

50

AUTHOR: Fayn, V. M.

TITLE: Time correlations of quantities described by kinetic equations 21

SOURCE: Zhurnal eksper. i teor. fiziki, v. 44, no. 6, 1963, 1915-1919

TOPIC TAGS: kinetic equation, time correlation, statistical mean, non-equilibrium processe, non-stationary processe

ABSTRACT: A series of general relations is established with which to find the time correlations of statistical quantities by means of kinetic equations. The method employed does not use the Callen-Welton theorem and is suitable in particular for finding the correlation functions in nonequilibrium and in nonstationary processes. The method is essentially a generalization of the method used by Leontovich (J. of Physics, v. 4, 499, 1941) for the calculation of stationary correlations of quantities whose mean values obey linear equations. In some cases it is sufficient to know the equations which the mean values of some quantities obey in order to find the correlations. The results are applied to a discussion of the case of a harmonic oscillator with friction. It is concluded that the role of the time correlation of a dissipative system is played by the

Card 1/2

L 13640-63
ACCESSION NR: AP3003121

2

quantity h/kT at high temperature and by the reciprocal of the natural frequency at low temperatures. "In conclusion, the author thanks V. I. Bespalov for valuable discussions of the results of the work." Orig. art. has: 32 formulas.

ASSOCIATION: Radiofizicheskiy institut Gor'kovskogo gosudarstvennogo universiteta (Radiophysics Institute, Gor'kiy State University)

SUBMITTED: 06Nov62 DATE ACQ: 23Jul63 ENCL: 00

SUB CODE: 00 NO REF SOV: 010 OTHER: 007

Card 2/2

FAYN, V.M.

Principle of the increase of entropy and the quantum theory of relaxation. Usp. fiz. nauk 79 no.4:641-690 Ap '63. (MIRA 16:3)
(Entropy) (Quantum theory)

S/0181/64/006/005/1320/1324

ACCESSION NR: AP4034908

AUTHORS: Genkin, V. N.; Fayn, V. M.

TITLE: Behavior of spin systems in a strong variable field

SOURCE: Fizika tverdogo tela, v. 6, no. 5, 1964, 1320-1324

TOPIC TAGS: spin, spin relaxation, nuclear magnetic resonance, magnetic field

ABSTRACT: The behavior of a spin system (spin $\frac{1}{2}$) is considered in a constant magnetic field $H_z = H_0$ and a variable field $H_x = \frac{h_1}{\gamma} \cos \omega t$; $H_y = -\frac{h_1}{\gamma} \sin \omega t$, where γ is the gyromagnetic ratio. The processes of spin-lattice relaxation are taken into account but the spin-spin interaction is neglected. This problem was considered by Bloch and others (F. Bloch. Phys. Rev., 105, 1206, 1957; R. Hubbord. Rev. Mod. Phys., 33, 249, 1961; K. Tomita. Progr. Theoret. Phys., 19, 541, 1958) but their results appear to be incorrect. The equations for the average value $\langle I^{\pm} \rangle$, $\langle I^{0} \rangle$ in a coordinate system rotating with frequency ω, where $I^{\pm} = (I_x \pm iI_y)$, $I^0 = I_z$, are found to be

$$\frac{d}{dt}\begin{pmatrix} \langle I^{-1} \rangle \\ \langle I^{0} \rangle \\ \langle I^{+1} \rangle \end{pmatrix} + \ldots$$

Card 1/3

ACCESSION NR: AP4034908

$$+\begin{pmatrix} -i\Delta_0+A_{-1-1} & i\omega_1+A_{-10} & A_{-11} \\ \frac{i\omega_1}{2}+A_{0-1} & A_{00} & -\frac{i\omega_1}{2}+A_{01} \\ A_{1-1} & -i\omega_1+A_{10} & i\Delta_0+A_{11} \end{pmatrix} \begin{pmatrix} \langle I^{\bullet -1}\rangle \\ \langle I^{\bullet 0}\rangle \\ \langle I^{\bullet 1}\rangle \end{pmatrix} = \begin{pmatrix} A_{-1} \\ A_0 \\ A_1 \end{pmatrix},$$

where $\Delta_0 = \omega_0 - \omega$ and $\omega_0 = \gamma H_0$.

Here $A_{\mu\mu'} = A_{-\mu-\mu'}$, $A_\mu = A_{-\mu}$ are of the form

$$A_{-1-1} = \sum_{\lambda\lambda'} B_{\lambda\lambda'} (q^\lambda_{-1} q^{\lambda'}_1 + q^\lambda_1 q^{\lambda'}_{-1} + q^\lambda_0 q^{\lambda'}_0),$$

$$A_{-10} = -\sum_{\lambda\lambda'} B_{\lambda\lambda'} (q^\lambda_1 q^{\lambda'}_0 + q^\lambda_0 q^{\lambda'}_1),$$

$$A_{-11} = -2 \sum_{\lambda\lambda'} B_{\lambda\lambda'} q^\lambda_1 q^{\lambda'}_1,$$

$$A_{01} = \frac{1}{2} \sum_{\lambda\lambda'} B_{\lambda\lambda'} (q^\lambda_0 q^{\lambda'}_1 + q^{\lambda'}_0 q^\lambda_1),$$

$$A_{00} = 2 \sum_{\lambda\lambda'} B_{\lambda\lambda'} (q^\lambda_1 q^{\lambda'}_{-1} + q^\lambda_{-1} q^{\lambda'}_1,$$

$$A_1 = \sum_{\lambda\lambda'} B_{\lambda\lambda'} (q^\lambda_1 q^{\lambda'}_0 - q^\lambda_0 q^{\lambda'}_1),$$

$$A_0 = \sum_{\lambda\lambda'} B_{\lambda\lambda'} (q^\lambda_{-1} q^{\lambda'}_1 - q^\lambda_1 q^{\lambda'}_{-1}),$$

Card 2/3

ACCESSION NR: AP4034908

and $B_{\lambda\lambda'} = \sum_{\mu} \Phi^{\mu-\mu} (\omega_{\lambda'-\mu}) \Delta (\omega'_{1+\lambda'}) p_{\lambda'}^{-\mu} p_{\lambda}^{\mu}$, where $\omega' = \sqrt{\omega_1^2 + \Delta_{\omega}^2}$. This result differs from that obtained by Bloch by the factor $\Delta[\omega(\lambda-\mu-\lambda')]$. However for weak fields this factor tends to unity, which coincides with the equation given by Bloch. The stationary solutions are given by a complicated expression which can also be given in the form $\langle I_y \rangle = 0;\ \cos\theta \langle I_z \rangle = \sin\theta \langle I_x \rangle$, where $\sin\theta = \frac{\omega_1}{\omega'}$; $\cos\theta = \frac{\Delta_0}{\omega'}$. Orig. art. has: 51 equations.

ASSOCIATION: Nauchno-issledovatel'skiy radiofizicheskiy institut Gor'kiy (Scientific Research Institute of Radiophysics)

SUBMITTED: 28Oct63 DATE ACQ: 20May64 ENCL: 00

SUB CODE: SS, GP NO REF SOV: 004 OTHER: 004

Card 3/3

ACCESSION NR: AP4019239 S/0056/64/046/002/0695/0709

AUTHORS: Fayn, V. M.; Yashchin, E. G.

TITLE: Contribution to the theory of stimulated Raman emission

SOURCE: Zhurnal eksper. i teor. fiz., v. 46, no. 2, 1964, 695-709

TOPIC TAGS: Raman emission, stimulated emission, stimulated Raman scattering, Raman laser self excitation, laser self excitation, fluctuation dissipation theorem, parametric generator, anti Stokes component, laser frequency doubling

ABSTRACT: In view of the recent feasibility of observation of different many-quantum light radiation and absorption processes owing to the development of lasers, the authors construct a theory of two-quantum processes without limitations on the spectrum of the atoms (or molecules) or the fields: this theory deals with the general behavior of an arbitrary quantum system capable

Card 1/3

ACCESSION NR: AP4019239

of resonance absorption in the presence of external forces. An analog is derived of the fluctuation-dissipation theorem, relating the noise in the presence of the external force to the susceptibility of the system in the presence of the same force. This is followed by an analysis of the interaction between electromagnetic waves with inclusion of stimulated Raman emission and a derivation of the self-excitation condition for a Raman laser. The connection between Raman lasers and parametric systems is also discussed. It is shown specifically that if the system under consideration has a natural frequency ω_0 and if it is acted upon by a signal with frequency $\omega_1 > \omega_0$, then negative absorption is produced at a frequency $\omega_2 = \omega_1 - \omega_0 < \omega_1$, so that the system can become unstable against a signal at a frequency ω_2. Such an instability can occur in particular in a plasma acted upon by an electromagnetic field. It is also noted that by using stimulated Raman emission at a frequency $\omega_2 = 2\omega_1$ (anti-Stokes

Card 2/3

ACCESSION NR: AP4019239

component) it is possible to produce frequency doubling within the laser itself, since the molecular system in the laser is in an inverted state. Orig. art. has: 52 formulas.

ASSOCIATION: Nauchno-issledovatel'skiy radiofizicheskiy institut pri Gor'kovskom universitete (Scientific Research Radiophysics Institute at Gor'kiy University)

SUBMITTED: 16Jul63 DATE ACQ: 27Mar64 ENCL: 00

SUB CODE: PH NO REF SOV: 008 OTHER: 009

Card 3/3

GENKIN, V.N.; FAYN, V.M.

Theory of the behavior of spin systems in the presence of a high variable field. Fiz. tver. tela 6 no.5:1320-1324 My '64. (MIRA 17:9)

1. Nauchno-issledovatel'skiy radiofizicheskiy institut, Gor'kiy.

FAYN, V.M.; KHANIN, Ya.I.; YASHCHIN, E.G.

Let er to the editor. Izv. vys. ucheb. zav. radiofiz. 7 no.2: 386 '64 (MIRA 18:1)

L 3527-66 EWA(k)/FBD/EWT(1)/EEC(k)-2/T/EWP(k)/EWA(m)-2/EWA(h) SCTB/IJP(c) WG
AM5013202 BOOK EXPLOITATION UR/
621.378.001 88 60 B+1

Fayn, Veniamin Moiseyevich; 44 Khanin, Yakov Izrailevich 44

Quantum radio physics (Kvantovaya radiofizika) Moscow, Izd-vo "Sovetskoye radio", 1965. 608 p. illus., biblio., indices. Errata slip inserted. 11,500 copies printed.

TOPIC TAGS: laser, 26,44 quantum theory, perturbation theory, field theory, spontaneous radiation, induced radiation, resonator theory, nonlinear optical effect, maser, paramagnetic amplifier, TW amplifier, laser theory, gas laser

PURPOSE AND COVERAGE: This book is intended for scientists and engineers working in the field of quantum radio physics and for students in advanced courses in schools of higher education and aspirants specializing in physics. It may also be useful to physicists and engineers engaged in related fields. A series of problems on the theory of the interaction between radiation and a substance is reviewed. Elements of the theory of quantum amplifiers and generators are discussed and the results of experiments are reviewed. The reader is assumed to have a knowledge of quantum mechanics equivalent to that of a university student. The material compiled in the book is presented in such a way that the reader has

Card 1/8

28

no need to refer to supplementary literature. The authors attempt to shed light upon the major results of existing acheivements in this field. Special attention was paid to those investigations in which the authors themselves participated. The experimental material was only reviewed, and for this reason little space is given to the descriptions of technical details. Sections 1-20, 22-40, and 71 were written by V. M. Fayn; Sections 41-49 and 51-59 by Ya. I. Khanin; Section 21 by V. N. Genkin; 44 Section 50 by E. G. Yashchin; Section 59, 60 by V. I. Talanov, 44 and Sections 61-70 by Ye. L. Rosenberg. 44 The authors thank A. V. Gaponov, Professor V. L. Ginzburg, Professor A. P. Aleksandrov, 44 V. N. Genkin, G. M. Genkin, 44 N. G. Golubeva, 44 G. L. Gurevich, 44 G. K. Tvanova, M. I. Kheyfets, Yu. G. Khronopulo, Ye. I. Yakubovich, and E. G. Yashchin for their cooperation.

TABLE OF CONTENTS:

L 3527-66
AM5013202

PART I. THEORETICAL BASES

Card 3/8

L 3527-66
AM5013202

Card 4/8

L 3527-66
AM5013202

L 3527-66
AM5013202

PART II. QUANTUM AMPLIFIERS AND GENERATORS

L 3527-66
AM5013202

Card 7/8