NEW METHOD OF MASER TUNING

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A maser with two resonators in series was investigated in detail in [1-5]. It was shown, in particular, that the amplitude and phase of the field in the second resonator are given by the expression [5]

$$E \sim (N/Z_{\mathrm{eff}})\langle P(\tau_1,\tau_2)\rangle \exp[-i(\omega_{21} - \omega_1)T] \tag{1}$$

where P is a function that depends on the intensity of the field in the first resonator and on the transit time through the first (τ_1) and second (τ_2) resonators, N is the number of molecules per unit volume, Z_{eff} the effective impedance of the resonator with account of the presence of molecules in it, ω_1 the frequency of the oscillations in the first resonator, and ω_{21} the frequency of the molecular transition. The symbol $\langle\,\rangle$ denotes averaging over the molecule velocities, and T is the travel time of the molecules between the resonators.

It is easy to see from (1) that when $\omega_{21} \neq \omega_1$ the phase difference of the oscillations in the first and second resonators depends on the distance ℓ between them (when $\omega_{21} = \omega_1$ the phase difference is equal to zero for any ℓ). This makes it possible to tune the maser frequency ω_1 exactly to the transition frequency ω_{21}.

Indeed, if we vary the distance between resonators by an amount $\Delta\ell$, then the phase of the oscillations in the second resonator will change by the amount

$$\Delta\psi = (\omega_1 - \omega_{21})(\Delta\ell/\overline{v}) \tag{2}$$

where $\overline{v}$ is the velocity of the molecular beam.

If we put $\Delta\ell \approx 10$ cm, $\overline{v} = 5 \times 10^4$ cm/sec, and $\omega_1 - \omega_{21} = 10^{-10}\omega_{21}$, then $\Delta\psi \approx 2 \times 10^{-4}$, corresponding to an approximate change of 0.01° in the phase angle. Such accuracy of the phase measurement will make it possible to tune the maser frequency accurate to 10^{-10}.

It is possible also to modulate the distance between resonators in accordance with the law $\Delta\ell = \Delta\ell_0 \cos\Omega t$. This leads to a phase modulation of the field in the second resonator, as a result of the periodic change in the transit time $T = \ell(t)/\overline{v}$. The phase-modulation amplitude is determined by expression (2). The use of periodic modulation of the distance between resonators can help appreciably in the registration of small changes in the phases of the oscillations in the first and second resonators, for this makes possible the use of a synchronous detection procedure.

The advantage of the proposed tuning method lies in the fact that it eliminates the influence of the traveling wave on the tuned frequency. If the spectral line used for the generation consists of one component, the frequency ω_1 will then coincide with the transition frequency ω_{21}.

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INFLUENCE OF TOROIDAL DRIFT ON PLASMA INJECTION TRANSVERSELY TO THE MAGNETIC FIELD

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One method of injection into magnetic traps, which has recently assumed a major role, is plasma injection transveresely to the magnetic field, using the effect of polarization interaction between the colliding streams [1-3]. An experimental check on the possibility of filling with plasma a toroidal trap with a bifilar stellarator field has demonstrated effective capture of the plasma [4].

It was observed in an investigation of the motion of plasma jets in a transverse magnetic field that the plasma penetrates quite well through the magnetic barrier, in spite of the fact that the magnetic pressure greatly exceeds the kinetic pressure ($H^2/8\pi \gg p$). This effect is due to the occurrence of electric polarization of the plasma moving in the transverse magnetic field. This leads, in turn, to drift in the self-consistent crossed fields, with a velocity that coincides in direction with the initial velocity. In addition to conservation of the transverse motion, an intense plasma flux is observed along the field force lines, the longitudinal velocity of which can be of the same order as the transverse one. In the case of transverse injection of a plasma in a toroidal magnetic field, there should be superimposed on these motions also a toroidal drift due to the polarization fields produced by the centrifugal drift and the drift of the oppositely-charged plasma components in the inhomogeneous field. Indeed, the toroidal drift leads to fully defined electric polarization fields, which can either coincide with or be opposite to the electric fields produced when the plasma moves across the magnetic field. We can therefore expect the plasma distribution through the trap volume to depend on the initial conditions, namely on the direction of the plasma-current velocity vector relative to the magnetic-field gradient.

To check on these assumptions, we investigated the motion of a plasma in a toroidal magnetic field. The experiments were made in a set-up comprising a toroidal stainless-steel vacuum chamber (major and minor diameters of torus 120 and 10 cm, respectively). The chamber was placed in the magnetic system of a sectionalized solenoid, which produced a quasi-stationary field (maximum field ~ 3 kOe, half-cycle duration $\sim 2 \times 10^{-3}$ sec). The plasma was injected by means of two spark sources at the same azimuth in the plane of the torus ($\phi = 0$). The internal and external injectors are so located that they produce an initial plasma-current velocity parallel and antiparallel to $\overline{\nabla H^2}$, respectively. The plasma current captured in the trap was mea-