3.27 Turbulence in the positive column of a glow discharge

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It is known that in the positive column of a glow discharge of noble gases the random ionization waves appear in some range of the gas pressure and discharge current[1]. With an appropriate choice of the discharge parameters, and sometimes superposing an external longitudinal magnetic field of some hundred gauss, it can be achieved that the column becomes convectively unstable. The growth constant of the ionization waves can be varied by changing the discharge parameters. In the vicinity of the frequency ω_0, where the imaginary part k_i of the wave vector has its maximum, k_i is given by an approximative relation

$$k_i = C_1 - C_2(\omega_0 - \omega)^2,$$

where C_1 and C_2 are constants depending on discharge conditions. It appears that the positive column acts as a selective amplifier.

In this report some preliminary results of measurements of the propagation of externally excited ionization waves in a weakly convective unstable positive column of the argon glow discharge are given.

The discharge tube with 2 cm of I. D. and 170 cm long was placed into a longitudinal magnetic field of 1000 gauss. At the discharge current of 10 mA and argon pressure $p=0.1$ torr, k_i takes such a value that the positive culumn can be be divided into three regions. In the cathode-side or linear region the linear theory of the ionization waves can be used for the description of the propagation of these waves. In the anode side the fully developed random ionization waves are present. This part of the positive column may be called saturated or turbulent region where the nonlinear effects play the dominant role in the wave propagation. Between these two regions there is a transition region in which the nonlinear effects become effective.

In the turbulent region all essential properties of the fluctuations can be determined measuring space-time correlation functions of the fluctuating quantities[2] defined by the relation

$$R(z,\ t) = \langle n(z_0+z,\ t_0+t) \cdot n(z_0,\ t) \rangle.$$

In the transition region such measurements are less useful since there the fluctuations are function of the longitudinal position. For the description of the situation in transition and turbulent regions a nonlinear theory of the ionization waves is needed. Up to now practically nothing has been done in this field. It is possible to derive approximative relations that take into account some nonlinear effects. But these relations are very complicated and thus of little use for the practical calculations.

Results of our measurements are given in Figures 1 and 2. As the light detectors two photo field effect transistors were used.

In Fig. 1 the propagation of an externally excited ionization wave of 5 kHz is shown. On the top the signal from a phase sensitive amplifier is plotted. In the lower part of the figure the signals from a spectrum analyser for various positions of the sensor along the discharge tube are shown. In Fig. 2 development of the frequency spectra of two externally excited ionization waves is given. It is seen that going towards the anode the number of peaks in the frequency spectrum increases. Higher harmonics of both signals and sums and differences of frequencies appear. In the saturated region only a broad, turbulent, spectrum is observed. The nature of the nonlinear interactions between waves is now under investigations.

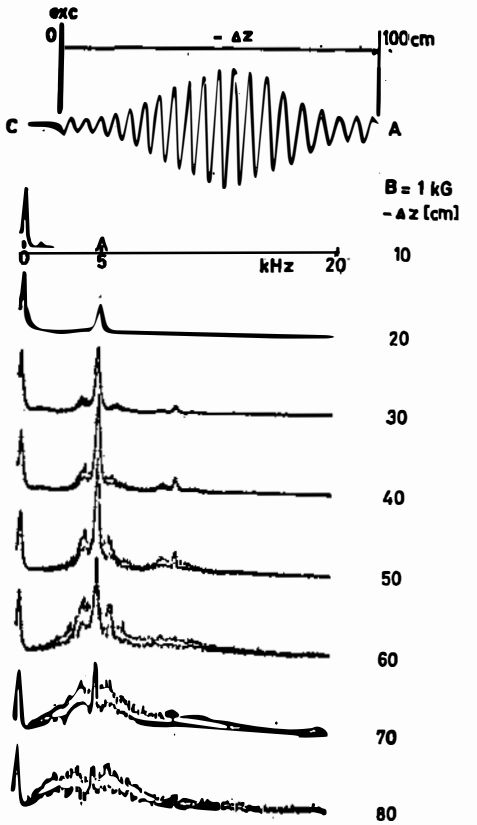

Fig. 1. The noise growth and propagation of an externally excited ionization wave in a weakly convective unstable positive column. Argon at $p=0.1$ torr, discharge current 10 mA. Δz is the distance of the detector from the exciter.

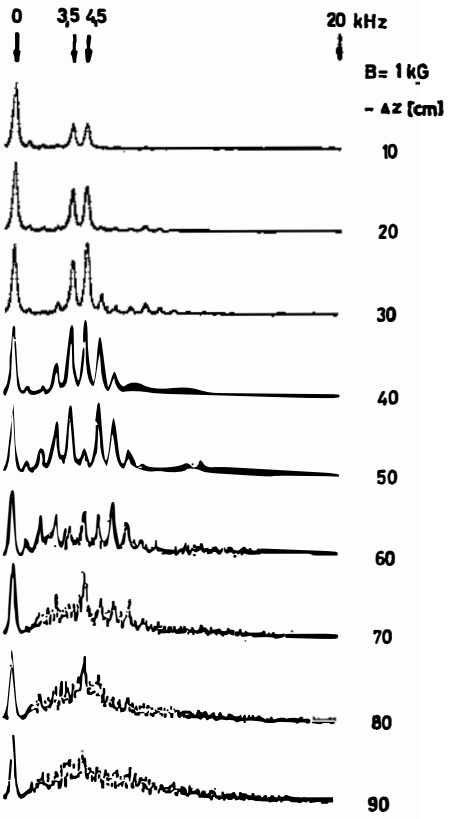

Fig. 2. The noise growth and propagation of two externally excited ionization waves in a weakly convective unstable positive column. Argon at $p=0.1$ torr, discharge current 10 mA.

References

1) L. Pekarek, Uspehi fiz. nauk **94** (1968) 463;
2) I. Grabec and S. Poberaj, Plasma Physics **11** (1969) 519.