Interaction Between Three Fireballs In Low-Temperature Plasma

S.A. Irimiciuc[1,2], C.T. Teodorescu-Soare[1], C. Ionita[2], D.G. Dimitriu[1], S. Popescu[1], M. Agop[3], B.S. Schneider,[2] R.W. Schrittwieser[2]

[1]*Faculty of Physics, Alexandru Ioan Cuza University, Iasi, Romania*

[2]*Institute for Ion Physics and Applied Physics, University of Innsbruck, Innsbruck, Austria*

[3]*Department of Physics, Gheorghe Asachi Technical University, Iasi, Romania*

Mesoscale science deals with structures between nano and macroscopic scales. It is the collective behavior of large numbers of atoms, molecules and nanoscale components which enable the creation of macroscopic systems and their control [1].

In plasma physics, fireballs can be considered as examples of structures born by mesoscopic processes. Fireballs appear in front of additional, positively biased electrodes in a thin plasma with a sufficiently high neutral background. They are intensely luminous complex space charge structures appearing as quasi-spherical intense luminous bodies, attached to the electrode. Consisting of a positive inner core (an ion-rich plasma), fireballs are confined by an electrical double layer which sustains a potential jump, i.e. an electric field. The stability of the double layer (DL) is assured by electrostatic forces that act as long-range correlation forces between the two adjacent opposite space charge accumulations (electrons and positive ions) of which the DL is formed. Numerous comprehensive investigations of various forms of fireballs have been carried out in Double Plasma (DP) machines [2].

Fig. 1. Three independent fireballs.

In this work we study the interactions between three independently produced fireballs as for their frequency behaviour in dependence on the distance between the electrodes and the background pressure which is proportional to the plasma density. Fig. 1 shows an example of three fireballs created independently on identical electrodes (1,5 cm diameter) in Ar at 10^{-2} mbar.

In Fig. 1 the two parallel (horizontal) electrodes are $d_{//}$ = 3 cm apart from each other and their fireballs oscillate with the same frequency (around 10 kHz) as long as the third (vertical) electrode is far away. For $d_{//} < 3$ cm the two horizontal fireballs begin to merge and the oscillation frequency decreases. For the third fireball (vertical electrode) a variation of the oscillation frequency with $d_{\perp}$ was observed (distance of the third electrode from the connecting axis between the two horizontal electrodes), attaining a maximum of 75 kHz for $d_{\perp} \cong 3$ cm. But already for $d_{\perp} < 5$ cm the third fireball begins to merge with the two others. Also the common frequency of the two horizontal fireballs varies with $d_{\perp}$. For $d_{\perp} <$ 2 cm the three fireballs oscillate with the same frequency. The behaviour is similar when $d_{//}$ is increased, i.e. when the two horizontal fireballs are less coupled.

Similar comprehensive investigations of the frequency behaviour were carried out when, for constant distances between the electrodes, the voltage applied on each electrode or the background pressure were varied.

[1] *From Quanta to Continuum: Opportunities for Mesoscale Science*, Report Basic Energy Sciences Adv. Com., Mesoscale Science Subcommittee, US Dep. Energy, Sept. 2012.

[2] R.L. Stenzel, C. Ionita, R. Schrittwieser, *Plasma Sources Sci. Technol.* **17**, 035006 (2008) (11pp) (doi: 10.1088/0963-0252/17/3/035006), and R.L. Stenzel, J.M. Urrutia, C. Ionita, R. Schrittwieser, *Contrib. Plasma Phys.* **51** (2011), 560-566 (doi: 10.1002/ctpp.201010158).