أكاديمية البحث العلمي والتكنولوجيا
ACADEMY OF SCIENTIFIC RESEARCH AND TECHNOLOGY

جامعة طنطا
TANTA UNIVERSITY

# Soliton waves in Radio frequency discharges

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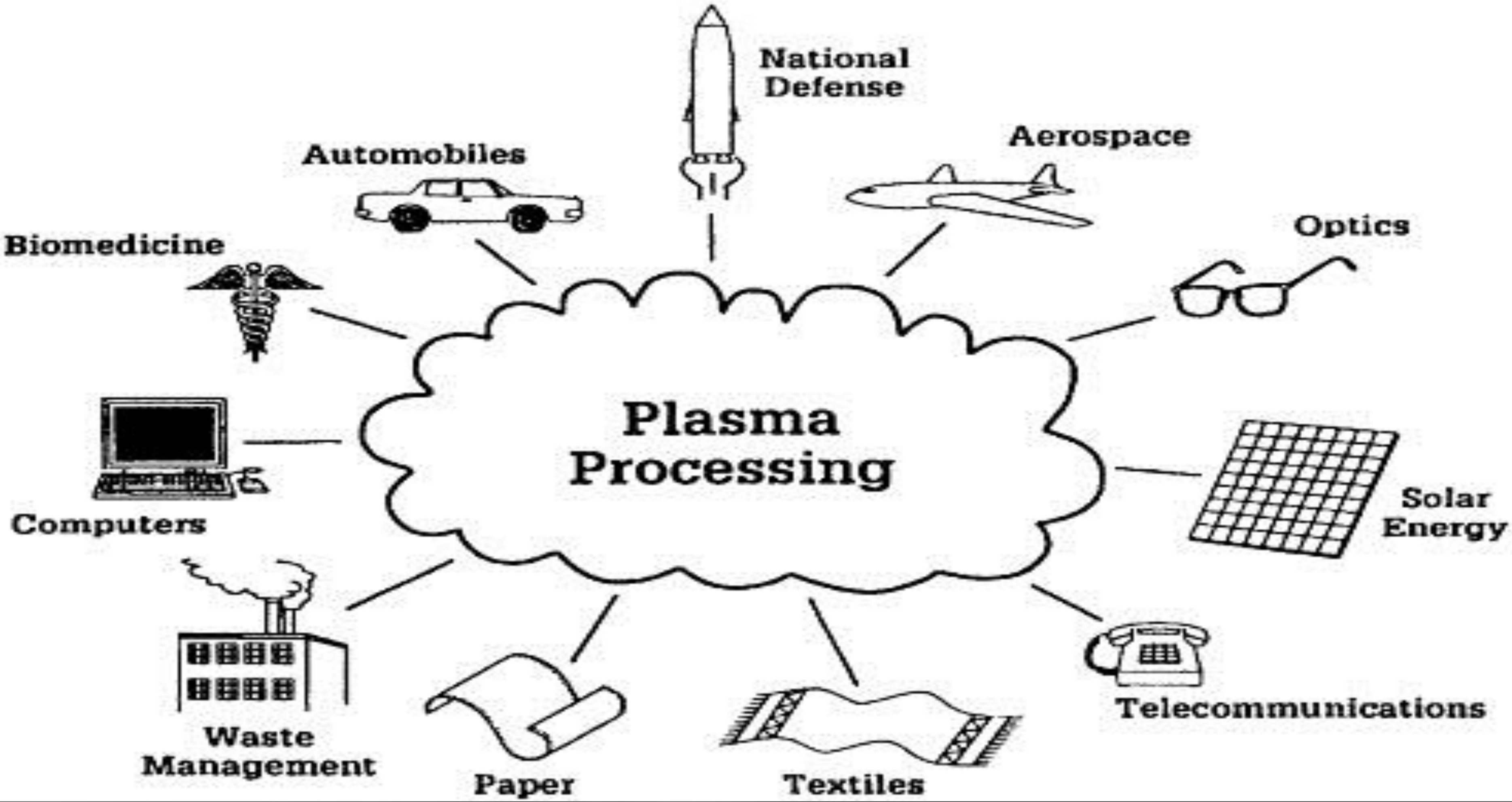
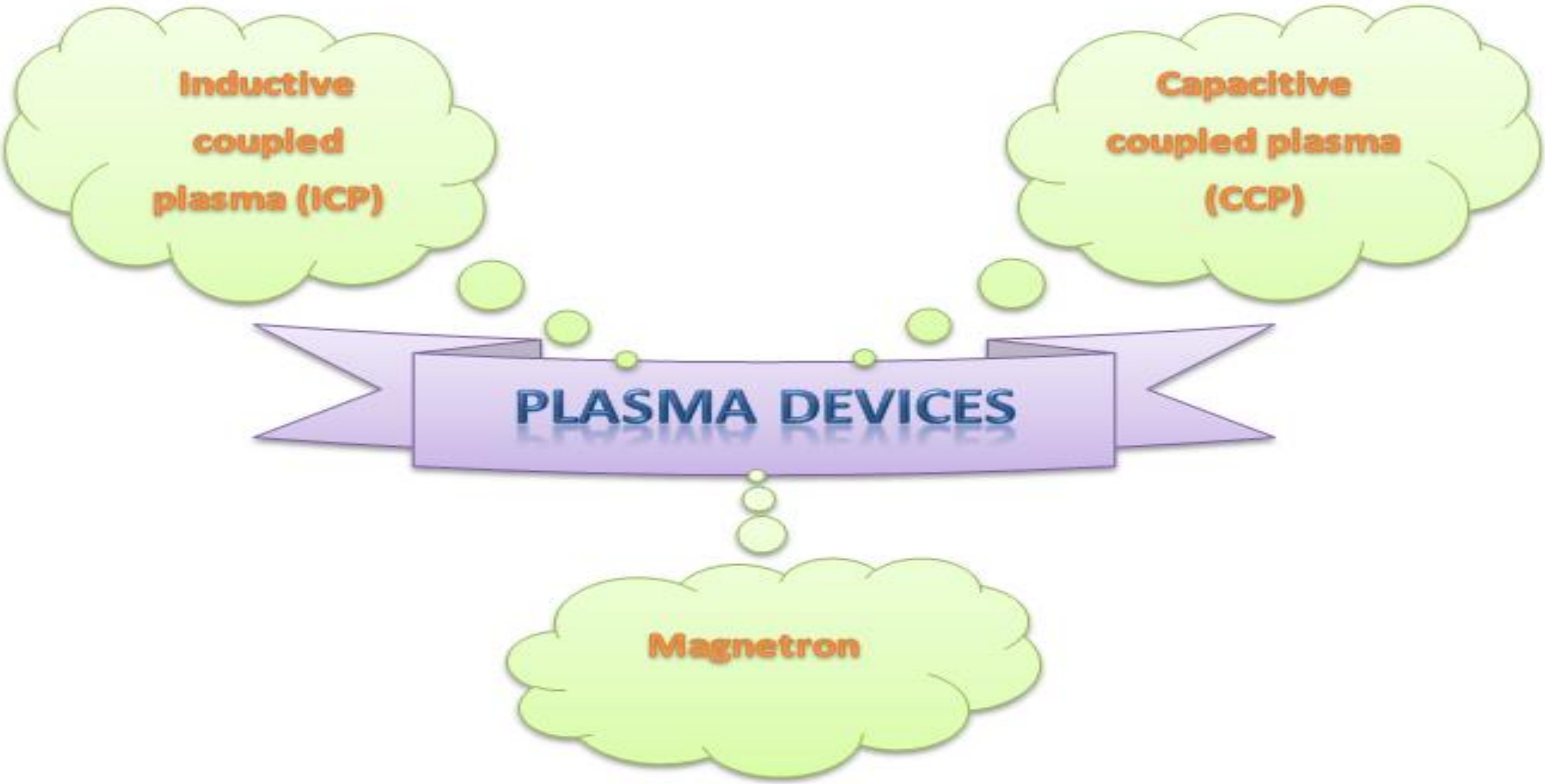
# Application of plasma




Inductive coupled plasma (ICP)
Capacitive coupled plasma (CCP)
PLASMA DEVICES
Magnetron

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# Capacitive Coupled plasma [CCP]

Between the two electrodes, which are connected to an alternating current ,there are two regions ;

Dark regions ,depletion layer of e- or even called plasma sheath which is near to the electrodes $n_e << n_i$

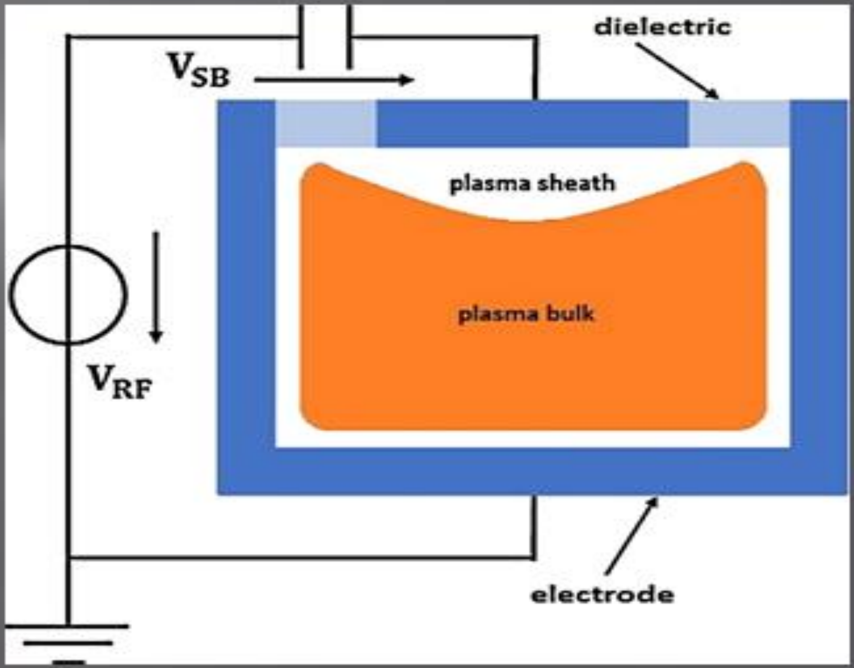
Bright region or Bulk Plasma ,where there is gas discharge ,is in the Middle between the electrodes

$n_e = n_i$ rich in e-

The bright region is due to being rich in e-

$$e + Ar \longrightarrow e + Ar^*$$

" excited"



# Uses of (CCP):-

- Plasma etching
- Plasma deposition
- Sputtering

# PARTICLE IN CELL SIMULATION

- An RF capacitively coupled plasma in Cartesian coordinates is simulated using a
1d3v Particle-in-Cell code.

- The code solves the equation of motion of the plasma superparticles in a self-consistent way with Poisson's equations assuming electrostatic approximation.

- The distance between the two planar electrodes is 15 cm and the gap size is discretized into 129 grids.

-The driven frequencies are 60 MHz and 1 MHz.

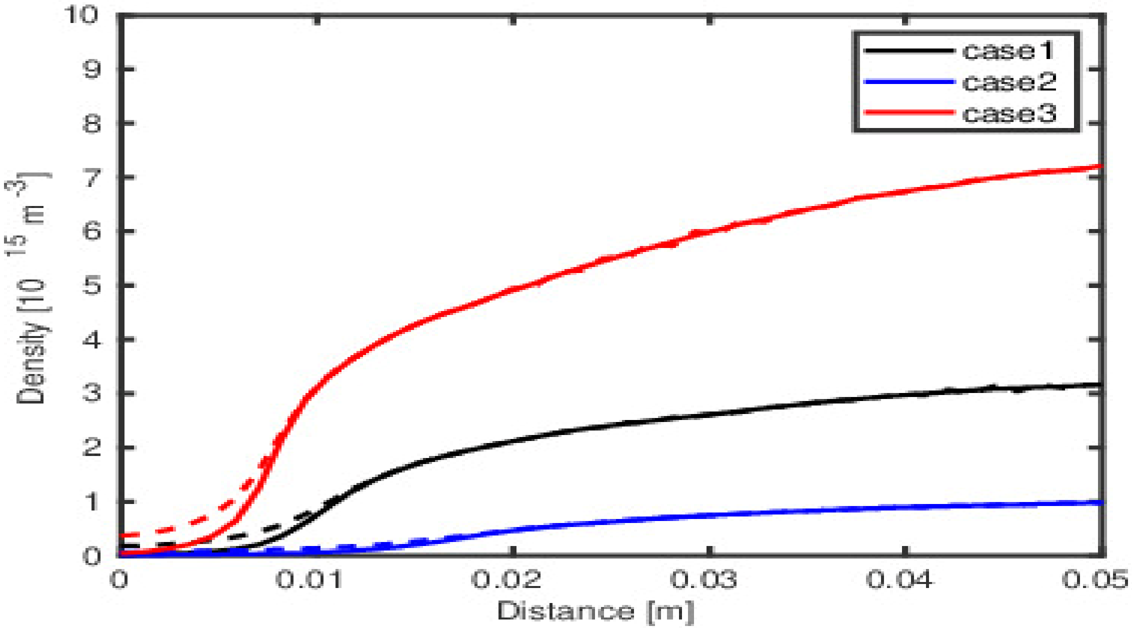
$$V_{\mathrm{RF}} = V_{60} \sin(2\pi\, 60\mathrm{MHz}\, t) + V_1 \sin(2\pi\, \mathrm{MHz}\, t).$$

The voltages of the frequencies change,

where the total is constant, . i.e, $V_{60}+V_1 = 500\text{V}$.

The simulation runs for 5000 RF periods of the 60 MHZ cycles.

The time step is 1/600 from the periodic time of the 60 MHz cycle. The simulation stops when there is no variation in the number of superparticles in the entire discharge, i.e., steady state.




The density profile corresponding to the steady-state solution.

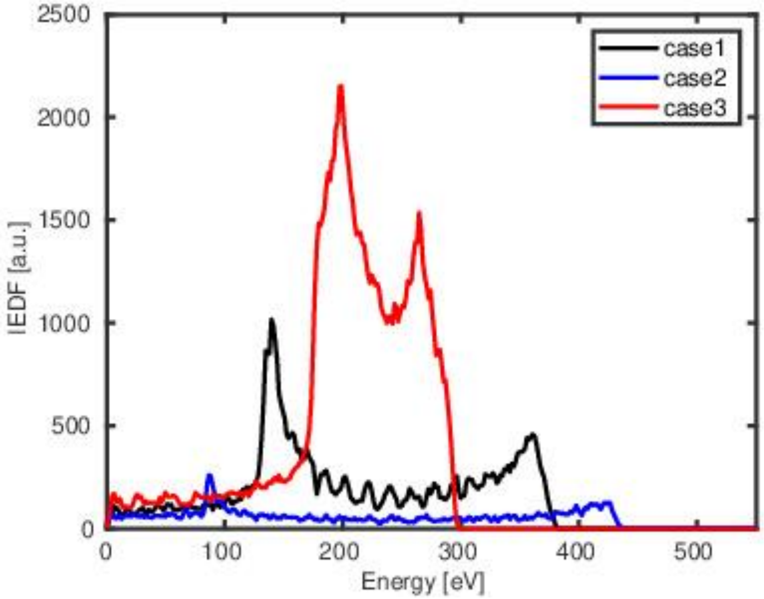
In case (1) the voltages are $V_{60} = 250$ V and $V_1 = 250$ V.

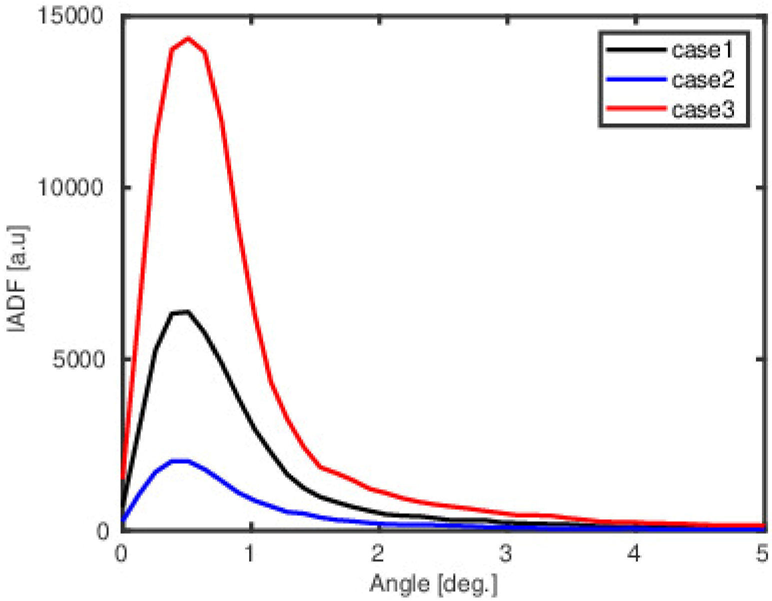
In case (2) the voltages are $V_{60} = 100$ V and $V_1 = 400$ V.

In case (3) the voltages are $V_{60} = 400$ V and $V_1 = 100$ V.

**By increasing the voltage of the 60 MHz signal, the bulk density increases, and a narrower sheath is achieved.**

**On contrary, increasing the amplitude of the 1 MHz frequency, the sheath extends significantly.**



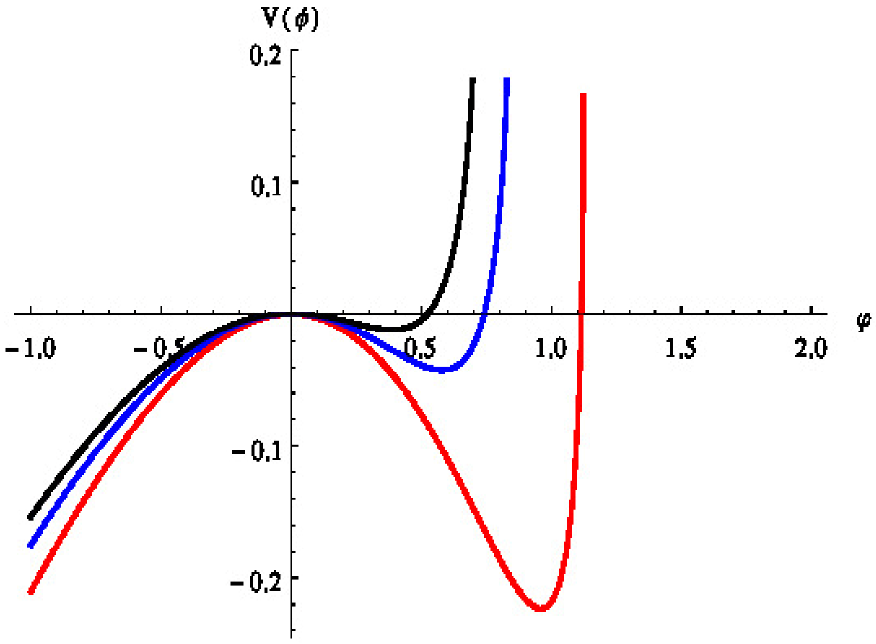



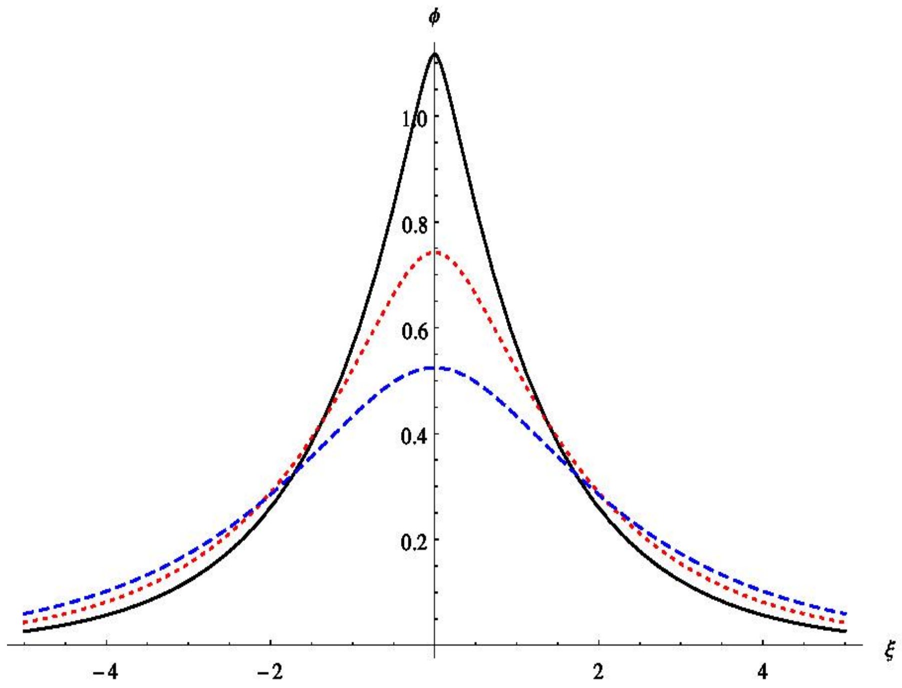

**When the voltage of the 1MHz is larger:**

**- A broadening of the Ion energy distribution occurs.**

**- The Ion angular distribution may allow anisotropic etching.**

# ION ACOUSTIC MODES AND SOLITONS




Solitons are present when

$$\omega_{\rm pe} \gg \omega_{\rm RF} \approx \omega_{\rm pi}.$$

## THANKS FOR YOUR ATTENTION

**The financial support by ASRT is acknowledged**