THE MAGO SYSTEM: CURRENT STATUS

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The research area known as MAGO (Russian abbreviation for *magnetic implosion*) in Russia and as MTF (Magnetized Target Fusion) in the United States is an alternative to the main CTF approaches (magnetic confinement systems and inertial confinement fusion – ICF). In distinction to the direct hydrodynamic compression of initially cold fuel (like in ICF), the MAGO/MTF approach consists of two phases:

1. First magnetized hot plasma is produced suitable for further compression (with magnetic field ~0.1 MGs having a closed field line configuration; the plasma is of density ~10^{18} cm^{-3}, temperature ~300 eV, and small enough impurity content, as impurities can contribute to the losses due to radiation).
2. Then the plasma is compressed in the quasi-adiabatic manner by liners (at velocities on the order of 1 cm/μs) using powerful drivers (for example, explosive magnetic generators, EMG) and its parameters are brought to the ones meeting the Lawson criterion.

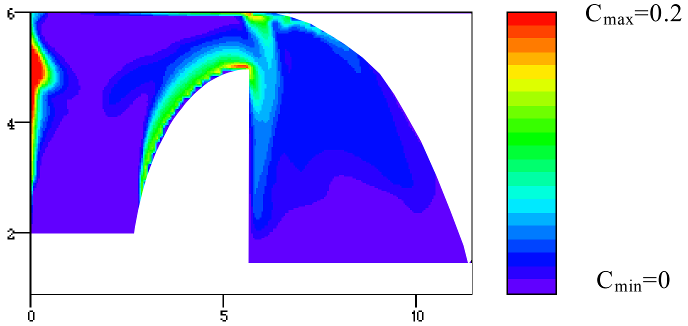
To use this approach, it is necessary to combine two essential elements: hot magnetized plasma generation system and quite highly energetic compression system.

In the MAGO chambers, DT plasma of the following parameters has been produced in a cylindrical bulk of 5-8 cm height, 6-10 cm outer radius, and 0.9-1.2 cm inner radius:

average density $8 \cdot 10^{17}$cm^{-3},
average temperature 200-250 eV,
characteristic azimuthal magnetic field in the plasma ~0.16 MG.

According to refs. (1,2), if the lifetime of that warm plasma is ~10^{-5} s, the ignition can be ensured using a compression by the liner of ~20 MJ energy and ~1 cm/μs velocity. In the joint VNIIEF/LANL experiment HEL-1 a liner of close parameters (~25 MJ energy, ~0.8 cm/μs velocity) was obtained(3). As 1D and 2D computations of pure plasma compression in a large chamber by a liner of the parameters close to those in the experiment HEL-1 show(4), the plasma of the characteristics corresponding to the Lawson criterion can be produced in this case. The data obtained in preliminary heating experiments using X-ray diodes, however, suggests ~2-3 μs plasma lifetime, which is insufficient to ensure ignition in compression.

Reasoning from the computed and experimental data, a most important mechanism that contributes to MAGO plasma cooling is contamination of the plasma with impurities and it's cooling due to irradiation on impurities. This plasma contamination can result from the plasma mixing with insulator vapors (which can be produced from *H*-released discharge(5)) and wall material washout by the plasma. To reduce the *H*-released discharge influence, preheating conditions should be ensured, under which there is no insulator evaporation.



Volume distribution of the copper impurities washed out by plasma from the walls

The influence of the electrode material washout by plasma on its contamination can be significant in view of the fact that heat fluxes from the plasma to the walls can lead to melting and even evaporation of the material on the surfaces, especially in the nozzle region. The figure presents the distribution over the chamber volume of copper impurities washed out by the plasma from 2D computation of MAGO performance for one of the recent experiments. The computations and estimations of turbulent washout show that at the preheating phase the plasma bulk contamination up to several wt % is possible, which can account for both the signal level of the probes recording X-radiation from the chamber and the plasma lifetime.

During the plasma compression in the MAGO chamber the mass washed out from the chamber walls can be even larger than that at the preheating phase. So walls made of light materials (carbon, beryllium or lithium for walls, beryllium oxide, boron carbide, boron nitride for insulator) should be used in experiments on DT plasma compression in the MAGO chamber. Using of light materials for the chamber walls and chamber insulator can increase the plasma lifetime and make the plasma suitable for the liner-plasma experiments.

For pure enough plasma the second neutron peak can be produced in plasma compression by the liner at ~0.8 cm/μs velocity at the plasma volume compression as low as ~10.

The nearest experiments on laboratory facilities and with involvement of EMG can verify the computational predictions and give answers to critical questions (such as mixing with wall material and plasma lifetime). These experiments could be considered as proof-of-principle tests of this way to the ignition.

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