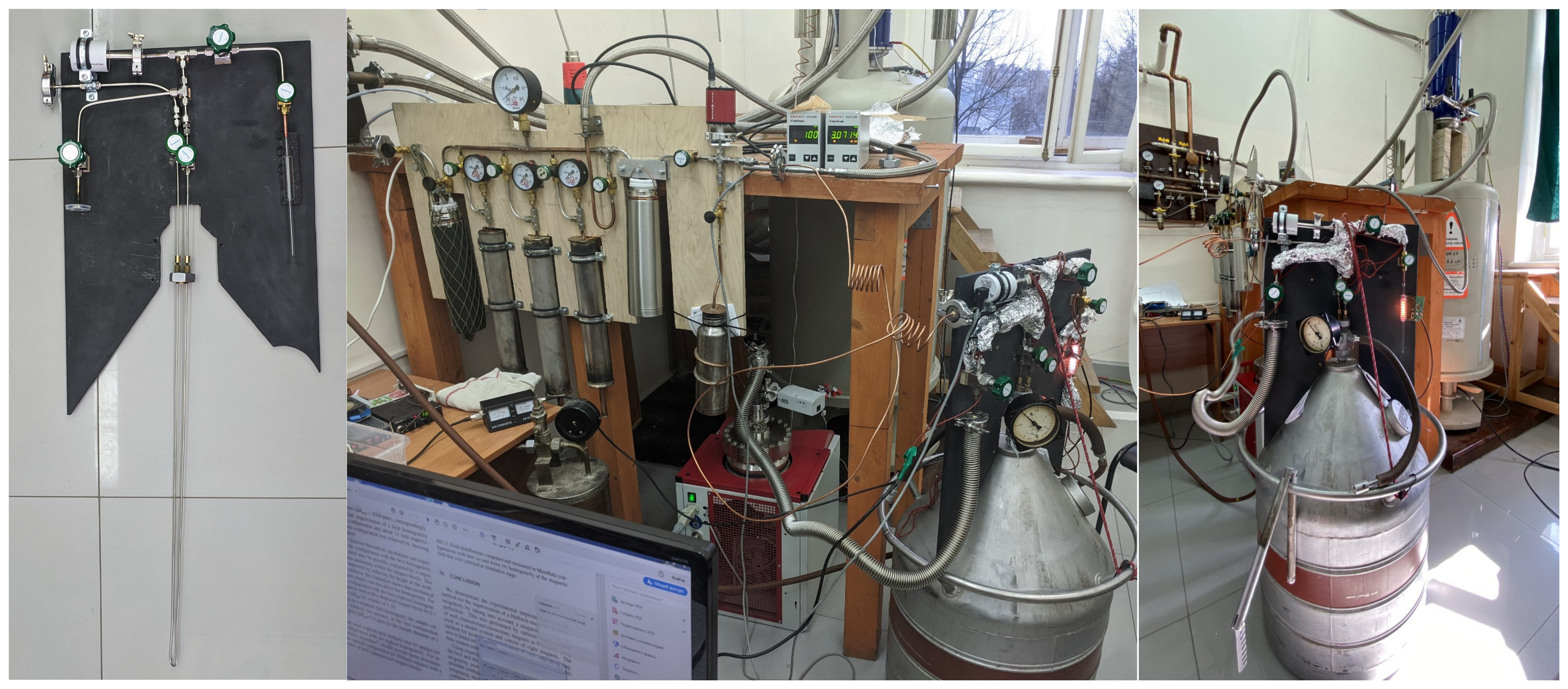
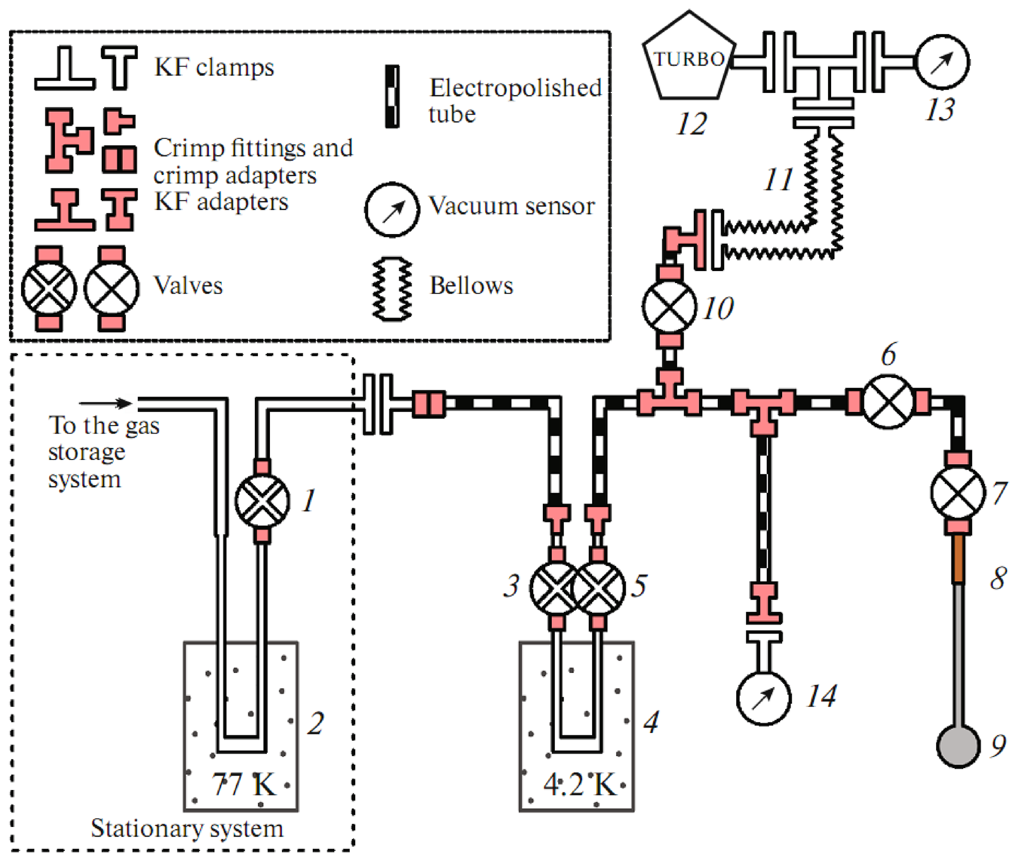
# Cryogenic purification of helium-3 gas for polarization purposes by PAMP method

**Vyacheslav KUZMIN, Kajum SAFIULLIN, Alexander MAKARCHENKO, Denis KAN, Murat TAGIROV***
*Institute of Physics, Kazan Federal University, Kazan 420008, Russian Federation*
**Tatarstan Academy of Sciences, Kazan 420111, Russian Federation*
Email: slava625@yandex.ru, kajum@inbox.ru

The novel PAMP polarization technique of helium-3 (polarization of atoms in a magnetized plasma [1]) yields at least a few percent helium-3 polarization at room temperature without the use of the optical pumping, solely by use of a strong external magnetic field and of a rf gas discharge in high-purity helium gas. The polarization process involves the metastable atoms, and similarly to MEOP is expected to require a high gas purity. Usually, commercial getter gas purifiers are used for helium-3 cleaning. Here we present a cryogenic approach for helium purification.



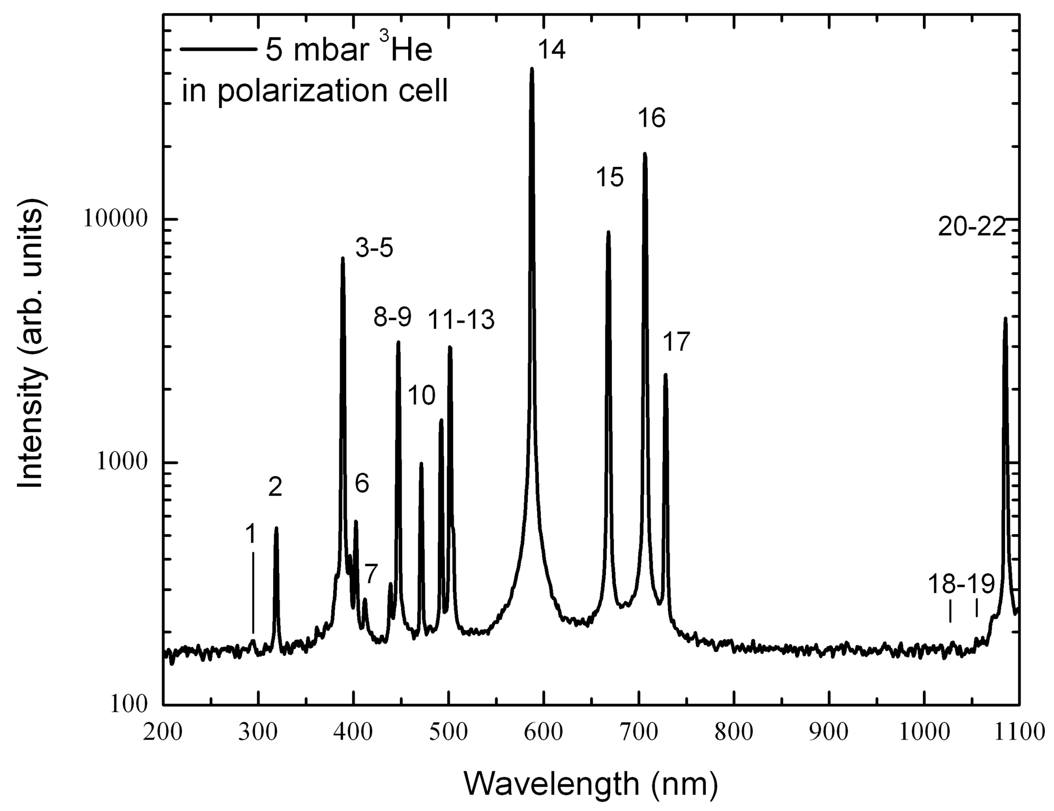
## Purification setup [2]




(1, 3, 5) Swagelok SS-2H valves, (2) nitrogen trap, **(4) U-shaped tube for purification at helium temperature**, (6, 7, 10) Swagelok SS-DSS4 valves, (8) glass-copper junction, (9) polarization cell, (11) bellows, (12) turbomolecular pump, (13, 14) vacuum sensors.

- ✓ Adapted for storage helium dewars
- ✓ Helium is deposited in cryotube (*4*) for >12 hours
- ✓ Allows for the polarizing cell filling
- ✓ Allows for many cycles of the cell cleaning
- ✓ Low additional liquid helium consumption <0.5 L/week
- ✓ Allows to work with a low grade helium (>99.99%)
- ✓ Suitable for cryogenic labs

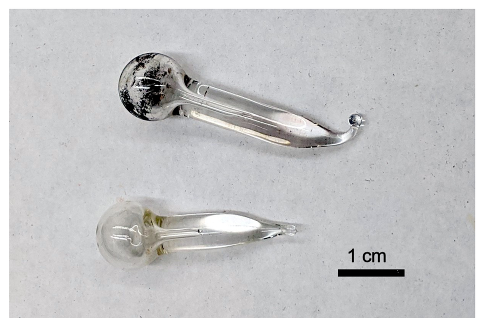
Optical emission spectrum of $^3$He plasma




✓ Only helium lines are visible

## NMR

$B_0$=3.66 T
Room temperature
Home-built pulsed NMR spectrometer [3]

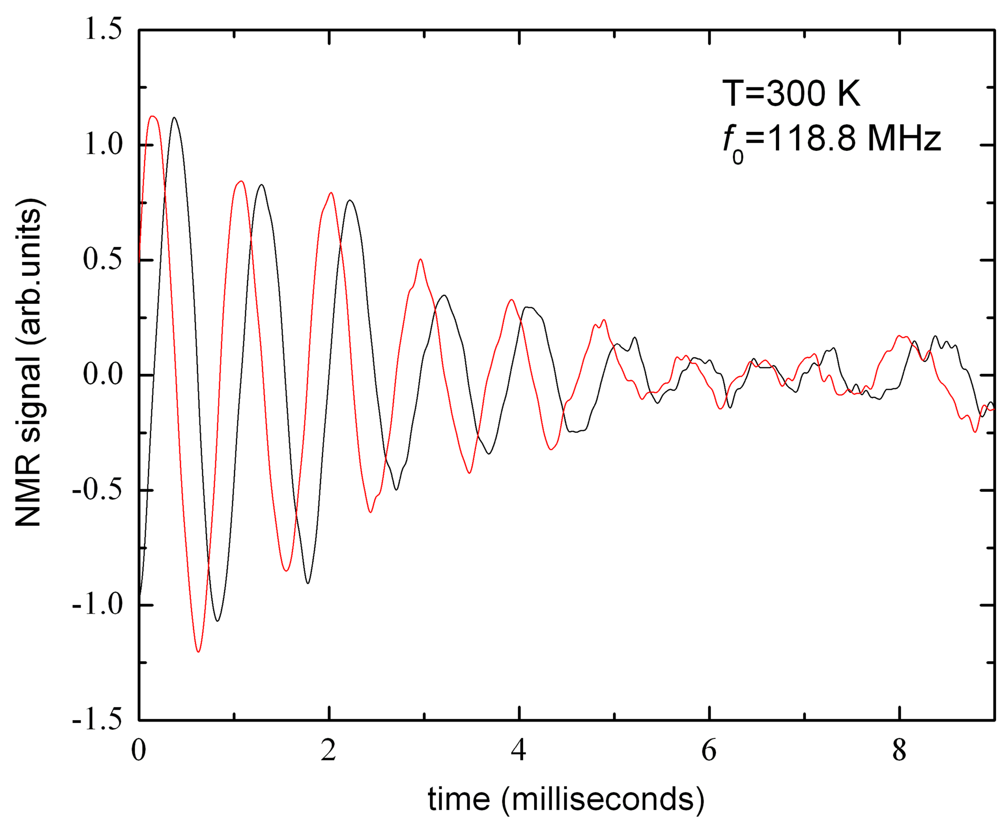


Sealed cells

89 mm 'warm' bore
Homogeneity:
5 ppm/cm
or 0.5 ppm/cm with shimming


Insert

$^3$He FID signal in 10 mbar cell




✓ 1% polarization
10 minutes rf discharge
at 27 MHz/12 W

## Perspectives

- ✓ PAMP process studies
- ✓ Porous media studies using $^3$He as a probe gas

## References

[1] Maul A. et al.,
Phys. Rev. A, 98, 063405 (2018).
doi:10.1103/PhysRevA.98.063405
[2] Makarchenko A. et al.,
Instrum. Exp. Tech., 64(6), 911 (2021).
doi:10.1134/S0020441221050213
[3] Kuzmin V.V. et al.,
Magn. Reson. Solids, 21, 19104 (2019)
doi:10.26907/mrsej-19104

Russian Science Foundation grant #19-72-10061