Multi-component Bose-Einstein condensates are currently intensively studied by experimental and theoretical groups.

One of the project directions concerns investigation of the influence of temperature on the Kibble-Zurek mechanism of spin domain creation in a harmonic trap. For a proper choice of parameters, some kinds of defects - spin domains - can be obtained in an anti-ferromagnetic spinor Bose-Einstein condensate of sodium atoms. The number of domains depends on the switch-on rate of one of the parameter of the system - the magnetic field. In a uniform system, the number of defects as a function of quench time scales according to Kibble-Zurek scaling predictions. However, when atoms are trapped in a harmonic potential, the scaling of the domains is different and the reason is not known. Finding the solution of this problem seems to be a very great scientific challenge.

The second topic of investigation concerns the influence of long-range dipolar interactions in Bose-Einstein condensates of atomic gases with a weak magnetic moment. In sodium condensates however, dipolar interactions were neglected due to the small magnetic moment. A recent better understanding of the long-range interactions and their resonant nature showed dipole effects in the weakly dipolar ferromagnetic rubidium gas for small magnetic fields. These values are hard to reach, but the experimental conditions are more favorable for sodium condensates. Investigation of the role of the weak dipolar interactions and their resonant properties in spinor Bose-Einstein condensate of sodium atoms can reveal a new view on ultra-cold antiferromagnetic atomic gases.

Analisys of the phenomena mentioned above will help in understanding current and future expreriments.