We investigated the influence of magnetic state of NdFe$_3$(BO$_3$)$_4$ on the permittivity $\varepsilon$ (magnetocapacitance (MC)) and the piezomodule $\varepsilon$ (magnetopiezoelectric effect (MPE)).

**The main results are:**

1. Below the Neel temperature (~32K) permittivity $\varepsilon_{xx}$ starts to increase almost linearly. At $H=0$ the growth of $\varepsilon$ turns to a slight decrease at $T_{cr}=13\pm 20$K(Fig.1). We associate $T_{cr}$ with the transition to a helicoid phase.
2. Piezomodulus $\varepsilon_{xx}$ below $T_{cr}$ goes down at first, but than starts to grow at $T_{cr}$ (Fig.2).
3. In the external magnetic field $H_{cr}$ applied in basal plane, the helical phase transformed to a “spin-flop” phase by means of the first-order phase transition (Fig.3). The $H_{cr}$ value doesn’t depend on the magnetic field direction (Fig.4). At Fig.5 it is presented the H-T diagram.

**Fig.1.** Temperature dependencies of dielectrical permittivity $\varepsilon$ at different external magnetic fields $H$.

**Fig.2.** Temperature dependencies of piezomodulus.

**Fig.3.** Field dependencies of dielectrical permittivity $\varepsilon$ in different angles $\varphi$ ($T=1.7$K). At $H=1$T the helical phase transfers to a “spin-flop” phase.

**Fig.4.** Angle dependence of $H_{cr}$ between $x$-$y$ axes. Opened circles - field up, filled down.

**Fig.5.** H-T diagram for NdFe$_3$(BO$_3$)$_4$. Opened circles - field up, filled -down.

**Fig.6.** The linear dependence of $\varepsilon$ from $H^2$.

•Phenomenological description can be given in frame of model, used in [1]. It is suggested that Nd ions are in the effective field $H_{eff}=\pm H_{ex}+H$, where $\pm H_{ex}$ exchange fields created by iron sublattices.

•We used thermodynamics potential like in [2]. For the related variations of $\varepsilon$ at $H \ll H_{ex}$ it was obtained:

$$\frac{\delta \varepsilon}{\varepsilon} \approx \frac{4\pi}{\chi \varepsilon} \left( a^2 - \frac{a_{Nd}}{a} - 6 \frac{H_{ex}}{\chi} + \frac{3}{2} \frac{\chi_{Nd}}{\chi} + \frac{1}{H^2} \right).$$

•Here $a$, $\chi$ - magnetoelctrical coefficients, $X_{Fe}$, $X_{Nd}$ - partial susceptibilities. The main features of these equations are the linear dependencies on $H^2$ shifted relative to the origin in the region of negative ordinates. These features are well confirmed experimentally (Fig.6). Using the known from the literature data on $H_{ex} (7.5 \pm 0.5$ T), $(X_{Fe}+X_{Nd})(1.38 \cdot 10^{-5}$ emu/cm$^3$) and $\varepsilon (\varepsilon_{ex}=15)$ at $T=1.7$K it was found that $a_{ex}+a_{Nd} = 450$ $\mu$C/m$^2$. Expected value of the electrical polarization at $H_{ex} \approx 225$ $\mu$C/m$^2$, that is comparable with the measured one [1]. We notice also that the magnetoelctrical coefficients have different signs and their ratio is $|a_{ex}/a_{Nd}|=0.2$.

