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CR-05. Negative magnetization induced by proton irradiation in the $CoCr_2O_4$ Multiferroic materials. *K. Choi*[1], S. Kim[1] and C. Kim[1]*1. Physics, Kookmin Univ., Seoul, South Korea*

We have investigated the magnetic properties of ^{57}Fe-doped $CoCr_2O_4$ compounds, proton-irradiated with 0, 5 and 10 pC/μm^2. The x-ray diffraction patterns for all samples irradiated by proton were determined to be a cubic structure with a space group Fd3(-)m. Zero field cooling(ZFC) curves showed the three specific transition temperatures as follows: 1st transition from paramagnetic to ferrimagnetic phase at 97 K (T_N), 2nd transition from ferrimagetic (collinear) to conical magnetic (noncollinear) spin state at 27 K(T_S), and 3rd abnormal transition at 13 K (T_A) [1,2]. In case of $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$, the ZFC data with an applied field of 100 Oe shows that ZFC curve starts increasing steadily, but when the temperature reaches at 13 and 27 K, step-like increase in the curve is observed. Above 27 K, it starts increasing rapidly up to near T_N.The obtained magnetization values are as follow: - 0.01 emu/g (5 K), 0.04 emu/g (21 K), 0.06 emu/g (27 K). While, for the sample of $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$ irradiated by proton with 10 pC/μm^2, the ZFC data with an applied field of 100 Oe shows a completely different behavior in magnetization. It shows negative magnetization as follow: - 1.3 emu/g (5K), -1.0 emu/g (21K), -0.92 emu/g (27K). Also the gap of step-like phase transition at 13 and 27 K is enhanced as quantum phase transition, up to the field of 1 kOe. Furthermore, the maximum value of magnetization with applied field of 1 T for $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$ irradiated by proton with 10 pC/μm^2 has been increased from 5.42 emu/g to 5.78 emu/g. We suggest that the enhanced magnetization of $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$ with applied field of 1T and negative magnetization, less than 1 kOe, after proton irradiation with 10 pC/μm^2 can be attributed to the changes in spin-orbital coupling and exchange interaction induced by proton irradiation.

[1]. Y. Yamasaki, et al., Phys. Rev. Lett. 96, 207204 (2006). [2]. G. Lawes, et al., Phys. Rev. B 74, 024413 (2006).