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# Multiferroic $\text{Pb}(\text{Fe}_{1/2}\text{Nb}_{1/2})\text{O}_3$ Single Crystals: A Raman Scattering Study

A. F. García-Flores  
*Pennsylvania State University*

Dmitri A. Tenne  
*Boise State University*

W.J. Ren  
*Chinese Academy of Sciences*

X. X. Xi  
*Pennsylvania State University*

S. -W. Cheong  
*Rutgers University*

# Multiferroic $\text{Pb}(\text{Fe}_{1/2}\text{Nb}_{1/2})\text{O}_3$ Single Crystals: A Raman scattering study

A.F. García-Flores<sup>a,b,c</sup>, D.A. Tenne<sup>b</sup>, W.J.. Ren<sup>e</sup>, X.X.X. Xi<sup>a</sup>, and  
S.-W. Cheong<sup>d</sup>

<sup>a</sup>Department of Physics, the Pennsylvania State University, University Park, Pennsylvania 16802

<sup>b</sup>Department of Physics, Boise State University, Boise, Idaho 83725-1570

<sup>c</sup>Instituto de Física “Gleb Wataghin”, UNICAMP, C.P. 6165, 13083-970, Campinas-SP, Brazil

<sup>d</sup>Department of Physics and Astronomy, Rutgers University, Piscataway, New Jersey 08854, USA

<sup>e</sup>Shenyang National Laboratory for Materials Science, Institute of Metal Research and International Centre for Materials Physics, Chinese Academy of Sciences, Shenyang 110016, People's Republic of China

Among complex perovskite-type structure multiferroics  $[A(B'B'')\text{O}_3]$ , lead iron niobate  $\text{Pb}(\text{Fe}_{1/2}\text{Nb}_{1/2})\text{O}_3$  (PFN) discovered by Smolenskii *et al.*<sup>1</sup> is currently of interest because of its high dielectric constant diffuse phase transition<sup>2</sup> and magnetoelectric effect<sup>3,4</sup>. PFN presents ferroelectric transition below  $T_C \sim 350\text{-}395$  K and antiferromagnetic transition below  $T_N \sim 145$  K<sup>1-4</sup>.

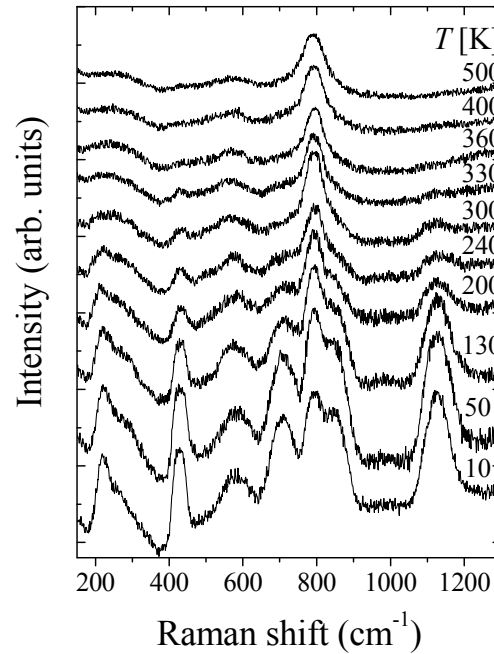
In PFN, the  $\text{Pb}^{2+}$  cations with a lone electron pair in  $A$  site and the relative displacements of oxygen and  $\text{Fe}^{3+}/\text{Nb}^{5+}$  ions in the octahedral  $B$  sites favor the electric ordering whereas the  $\text{Fe}^{3+}$  cations with partially filled  $d$  orbitals contribute to the magnetic ordering. Because of its complex structure, still exists a disagreement about the crystalline structure of PFN: monoclinic (space group  $\text{Cm}$ ), rhombohedral (space group  $\text{R}\bar{3}\text{m}$ ), and cubic (space group  $\text{Pm}\bar{3}\text{m}$ ) structure symmetry at room temperature were reported<sup>3,5,6</sup>.

In this work, we report temperature-dependent Raman spectra (10-500 K) in the frequency range of  $150\text{-}1250$   $\text{cm}^{-1}$  of cubic PFN single crystals, complemented with magnetization measurements. We want to provide microscopic information in this material.

Over the range from  $150$  to  $950$   $\text{cm}^{-1}$ , very broad and overlapping peaks (first-order character) were observed in the overall studied temperature range possibly due to local distortions which are characteristic in this kind of Pb-based complex perovskite. Also, a prominent high-frequency peak at  $\sim 1130$   $\text{cm}^{-1}$ , which we assign as a two-phonon peak, was observed (see Fig. 1).

Temperature dependence of the Raman spectra showed an anomaly in a characteristic temperature  $T^* \sim 330$  K. Here, drastic changes in the Raman scattering intensity and spectral shape were observed with temperature variations, such as the appearance of new first- and second- order peaks below  $T^*$ . The temperature behavior of the two-phonon peak shows a strong electron-phonon interaction in PFN. Also, since it was reported weak magnetic ordering at and even above room temperature in

this material, the anomaly at  $T^* \sim 330$  K by Raman scattering could be possibly suggesting an interplay between magnetic e ferroelectric orders.



**Figure 1: Raman spectra as a function of temperature in  $\text{Pb}(\text{Fe}_{1/2}\text{Nb}_{1/2})\text{O}_3$ .**

## ACKNOWLEDGMENTS

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