

Abstract Submitted  
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**Double Charge Ordering States and Spin Ordering State Observed in a  $\text{RFe}_2\text{O}_4$  System**<sup>1</sup> FEI SUN, RUI WANG, Institute of Physics, Chinese Academy of Sciences, CYNTHIA AKU-LEH, ISciences, Ann Arbor, Michigan, USA, HUAIXIN YANG, Institute of Physics, Chinese Academy of Sciences, RUI HE, Department of Physics, University of Northern Iowa, Cedar Falls, USA, JIMIN ZHAO, Institute of Physics, Chinese Academy of Sciences — Charge, spin, and lattice degrees of orderings are of great interest in the layered quantum material  $\text{RFe}_2\text{O}_4$  ( $\text{R} = \text{Y}, \text{Er}, \text{Yb}, \text{Tm}, \text{and Lu}$ ) system. Recently many unique properties have been found using various experimental methods. However so far the nature of the two-dimensional (2D) charge ordering (CO) state is not clear and no observation of its fine structure in energy has been reported. Here we report unambiguous observation of double 2D CO states at relatively high temperature in a polycrystalline  $\text{Er}_{0.1}\text{Yb}_{0.9}\text{Fe}_2\text{O}_4$  using Raman scattering. The energy gaps between the 3D and the double 2D states are 170 meV (41.2 THz) and 193 meV (46.6 THz), respectively. We also observed a spin ordering (SO) state at below 210 K with characteristic energy of 45 meV (10.7 THz). Our investigation experimentally identified new fine structures of quantum orders in the system, which also extends the capability of optical methods in investigating other layered quantum materials.

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