Evidence of Strong Lattice Effects in the Charge Order and Spin Density Wave Phases of $(TMTTF)_2X$ and $(TMTSF)_2X$ ($X=PF_6$)

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We present a neutron study carried out on the so-called strongly correlated quarter-filled organic superconductors $(TMTTF)_2X$ and $(TMTSF)_2X$ which evidences a sizeable coupling between the lattice and the charge and spin electronic degrees of freedom. Firstly, we have investigated the molecular charge order (CO) - ferroelectric transition which was until now considered as a structureless transition. Recent thermal expansion measurements in $(TMTTF)_2X$, with $X=PF_6$ and AsF_6, have evidenced a coupling of the molecular charge order to the lattice and have lead to propose a structural model involving an in-phase shift of the anions directed to the $TMTTF^{+\delta}$ molecules. We present here, a direct measurement of the structural counterpart of the molecular CO transition performed on deuterated $(TMTTF)_2PF_6$ using powder neutron diffraction in order to avoid X-ray irradiation damages which kill the CO transition. Our results show that the intensity of some Bragg reflections is affected by the CO.

Secondly, we have studied the unconventional mixed $2k_F$ spin/charge density wave (SDW/CDW) ground state of $(TMTSF)_2PF_6$ using powder elastic neutron scattering. At low temperature, our measurements show an abnormally important thermal dependence of the intensity of Bragg reflections at small Bragg angles, suggesting the presence of an anomalously large Debye Waller thermal factor. The characteristic temperature deduced from this thermal factor is found to be very close to the critical temperature of the C/SDW transition. This result shows the presence of particularly soft lattice modes which could be coupled to the SDW transition, and which evidences the role of the lattice degrees of freedom in this unusual ground state.