



Report letter on the PhD thesis Charge Order in $Ir_{1-x}Pt_xTe_2$ and High-Energy Magnetic Excitations in $La_{2-x}Sr_xCuO_4$ by Oleh Ivashko

Paris, October 6th, 2018

Dear colleagues,

I am writing to you to give you my report on the PhD manuscript of Oleh Ivashko where he summarized his three years of research works at University of Zurich in the group of Pr. J. Chang. His works focus on the study, mainly by inelastic and elastic X-ray measurements, of the spin and charge degree of freedom in the superconducting alloys $Ir_{1-x}Pt_xTe_2$ and the high critical temperature superconductor $La_{2-x}Sr_xCuO_4$. His subject of research is at the heart of the contemporary condensed matter physics paradigm : the interplay between the different electronic and lattice order in superconducting systems.

His manuscript is divided in 7 chapters that I will briefly summarized :

In Chapter 1 he introduced the context and the problematic of his research which focus on the interplay of competing orders such as charge order or antiferromagnetic spin orders (respectively labelled CO, AF) and superconductivity order (SC). In his introduction I could appreciated his fine knowledge of the current literature on a subject which is extremely vaste.

In Chapter 2 he presented the samples, the pressure cell and the two X-rays technics : X-ray diffraction and RIXS (Resonant Inelastic X-ray scattering) that he used during his PhD. This chapter is followed by a theoretical chapter where he gives the cross-sections scattering for a RIXS experiment and the magnetic dispersion in the Hubbard model that he used in chapter 5 and 6.

In the three next chapter he presented the key results of his works. They can be summarized as follow.

In Chapter 4 he used the hydrostatic pressure to probe the interplay between a CO and the SC in Pt doped $IrTe_2$. His hard X-ray diffraction measurement on $Ir_{1-x}Pt_xTe_2$ with $x = 0:04$ and $x = 0:05$ shows that the CO is characterized by a dimer formation of $Ir_{3+}-Ir_{3+}$ with a modulation vector $q=(1/5,0,1/5)$ down to 20K in contrast to low doping samples. The use of pressure is particularly interesting in the case of $x=0.05$ since it allow him to restore the CO order and to show that it appears at a temperature different from a structural

transition. He finally concluded his chapter by discussing the implication of his observations to the broad superconducting transition observed at lower temperature.

In chapter 5 and 6 Oleh used RIXS to probe the AF spectrum in the doped $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ at $x=0.12\%$ and in the un-doped thin film grown by molecular beam epitaxy (MBE) technique on different substrates La_2CuO_4 . The aim of these experiments is to understand the nature of the AF excitations and their evolution with the doping and the strain. The understanding of these excitations is of fundamental interest for, at least, two reasons : (i) these excitations have been proposed as the binding Cooper pairs interaction for many years now (ii) they can be used to estimate the microscopic parameters of the Hubbard model. From this last point of view the works of Oleh is impressive. Early neutron scattering and more recently RIXS measurements has been conducted to evaluate these parameters. However the works of Oleh goes beyond by measuring the dispersion of these excitations on the whole Brillouin zone. He can then safely conclude that higher-order hopping terms t' and t'' has to be included in the Hubbard model, that the ratio of t'/t is constant and that the strain effect observed in the thin films La_2CuO_4 can be captured by simply varying the t term. These are important will result which will put strong constrain to any theorists interesting to this problem.

During the course of his PhD I have met Oleh at the end of his first and second year. While he was hesitating in his presentation and his response during my first visit I found a confident students in my second visit. I have been pleased to read a manuscript which materialize all his progress. His manuscript is of good quality : it is brief and goes to the essential key results. As a drawback a non expert may have appreciated a longer introduction on the problematic and on the experimental technics. I am confident that Oleh has all the quality to become an excellent research scientist in the field of X-ray scattering.

In conclusion I recommend this dissertation without hesitation to be accepted by the Faculty of Sciences of UZH.

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