令和２年度　９月修了

京 都 大 学 大 学 院 理 学 研 究 科

Ｄ Ｃ ３ 回 生 研 究 発 表 会
要旨集

２０２０年７月１４日（火）

物 理 学 第 一 分 野

物理学第一分野ＤＣ３回生研究発表会

場所：理学研究科５号館　５階・第四講義室
発表：２０分（別に質問１０分程度）

２０２０年7月１４日（火）１１：００～　開始

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Light-driven modulation of liquid-crystalline order in nematic phase

Soft Matter Physics Group Chiao-Ying Chien

Abstract We immobilize azobenzene through polymerization, fabricating the liquid crystal gels with azobenzene-containing copolymer microstructure and study their photo-induced spatial variation of birefringence (Δn). We clarify that the surface anchoring of microstructure is crucial in modulation of photo-induced change of Δn.

Recently, Samitsu et al. proposed a principle of the molecular manipulator which transport polymer through spatial variation of the scalar order parameter (S) in the nematic liquid crystal (LC) [1]. The spatial variation of S was generated by stimulating *trans*-to-*cis* isomerization of azobenzene derivatives in the nematic phase. Under UV light, the *trans*-azobenzene converts into *cis* form. The *cis*-azobenzene with a bent-like shape tends to destabilize the liquid-crystalline order, resulting in a decrease of S and the birefringence (Δn) of the nematic phase [2]. Based on this mechanism, the molecular manipulator provides a great potential to drive arbitrary nanometer-sized impurities in the nematic phase. However, this method has a limitation. The natural diffusion of azobenzene might cause poor spatial resolution of S, which obstructs the development of precisely-controlling the nm-sized impurities.

In this study, immobilization of azobenzene through polymerization is proposed to prevent the diffusion of azobenzene in the nematic phase. We fabricate nematic LC gels with phase-separation of azobenzene-containing copolymer microstructure. Unlike conventional photo-induced decrease of Δn in the azobenzene/nematic mixture, an increase of Δn is newly observed under UV irradiation in the LC gels (Fig. 1) [3]. To elucidate the anomalous increase of Δn, the photo-induced change of Δn and the morphology of the copolymer microstructure are investigated with the variant composition of LC gels. The shape of the copolymer microstructure, which have a finite anchoring strength on their surface, influence the LC director and result in a lower Δn before the UV irradiation. We find that the *trans*-to-*cis* isomerization of azobenzene weakens the surface anchoring of the copolymer microstructure. Hence, the LC directors recover their uniform distribution, and the increase of Δ*n* appears.

We tune the composition of LC gels to eliminate the anchoring effect of the copolymer microstructure [3] and evaluate the spatial resolution of the LC gels [4]. The photo-induced spatial variation of Δn of the non-polymerized and the polymerized samples are quantitatively compared through measuring their full-width-at-half-maximum (FWHM). The FWHM of the non-polymerized sample expands with time, while the polymerized sample remains the feature close to that of the stimulating light. The time evolution of Δn clearly shows that the photo-induced change of S is highly constrained in the irradiated area in the polymerized sample (Fig. 2). Based on these results, we conclude that the LC material for modulating the scalar order parameter with high spatial resolution has been achieved by our method.

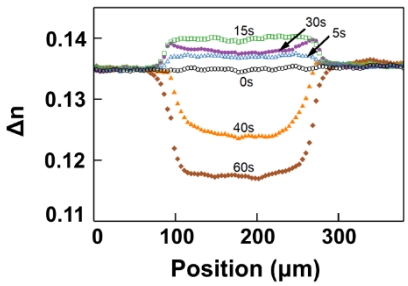

Fig. 1. Photo-induced spatial variation of Δn as a function of UV exposure time.

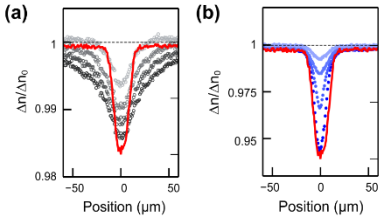

Fig. 2. Time evolution of photo-induced spatial variation of Δn in (a) non-polymerized and (b) polymerized samples, where red line is the UV light distribution.

References

[1] S. Samitsu *et al.*, Nat. Mater. **9**, 816 (2010).
[2] T. Ikeda, J. Mater. Chem. **13**, 2037 (2003).
[3] C.-Y. Chien *et al.*, submitted.
[4] C.-Y. Chien *et al.*, submitted.

Non-Fermi liquid transport properties near the nematic quantum critical point of $FeSe_{1-x}S_x$

Quantum Condensed Matter Group Wen-Kai Huang

Abstract To study how the nematic fluctuations affect the normal state transport properties, we have conducted charge transport measurements on $FeSe_{1-x}S_x$ superconductors. We found that the quantum nematic fluctuations can cause similar transport phenomena that have been observed in the case of antiferromagnetic fluctuations. Our results suggest that different types of quantum fluctuations could result the same anomalous charge transport behaviors.

Quantum phase transition is one of the central problems in strongly correlated materials. It has been discussed that quantum fluctuations of order parameter can become large when the system is near a quantum critical point (QCP), a point where a zero temperature transition happens by controlling some nonthermal parameters. It is believed that these quantum fluctuations can give rise to the non-Fermi liquid (NFL) behaviors and are responsible for unconventional superconductivity. Thus, understanding the physics associated with quantum fluctuations is of primarily importance [1]. One canonical example of such QCP is an antiferromagnetic (AFM) QCP, which has been realized in a variety of correlated materials, such as heavy fermion compounds and cuprates. In this study, we focus on another type of QCP, i.e., a QCP of a nematic order that breaks the rotational symmetry of the underlying crystal lattice.

The iron-based superconductor $FeSe_{1-x}S_x$ is a multi-band compound which has a nematic QCP without magnetic order. For x = 0, a nematic order appears below T_s ~ 90 K. As the sulfur doping increases, the transition temperature T_s decreases, and finally becomes zero at x_c ~ 0.17. Around this nematic QCP, large nematic fluctuations have been observed by nematic susceptibility measurements, while AFM fluctuations are found to be negligible [2]. This indicates that $FeSe_{1-x}S_x$ is suitable to study the impact of nematic fluctuations.

Here, to investigate how the nematic fluctuations affect the transport properties, we measured the dc-resistivity, Hall effect and magnetoresistance at various doping levels across the nematic QCP of $FeSe_{1-x}S_x$. Near x_c = 0.17, we found that the resistivity shows linear dependence on temperature at low temperatures, as shown in Fig.1, and the Hall angle $\cot\theta_H$ (= ρ_{xy}/ρ_{xx}) is proportional to T^2. Moreover, the magnetoresistance obeys modified Kohler's rule ($\Delta\rho_{xx}/\rho_{xx} \propto \tan^2\theta_H$). These transport properties near x_c = 0.17 provide evidence for the NFL behaviors due to nematic QCP. It should be note that the AFM fluctuations can also lead to the similar anomalous transport behaviors [3]. Our results suggest that different types of quantum fluctuations could result the same anomalous charge transport behaviors [4].

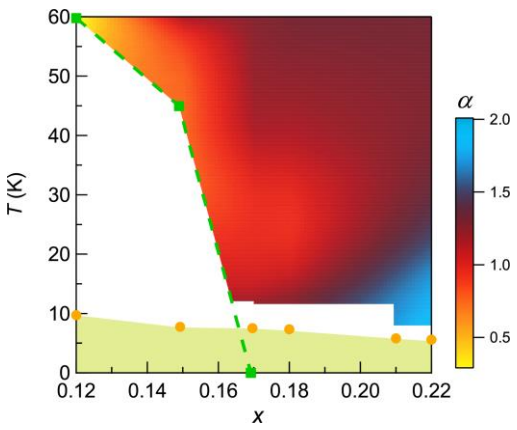

Fig. 1. Phase Diagram of $FeSe_{1-x}S_x$. Colors represent exponent α given by formula $\rho_{xx} = \rho_0 + AT^\alpha$. The green dot line represents nematic transition temperature T_s. $\alpha \approx 1$ near $x_c \approx 0.17$.

References

[1] H.v. Löhneysen *et al.*, Rev. Mod. Phys. **79**, 1015 (2007).
[2] P. Wiecki *et al.*, Phys. Rev. B **98**, 020507(R) (2018).
[3] H. Kontani, Rep. Prog. Phys. **71**, 026501 (2008).
[4] W. K. Huang *et al.*, submitted.