

## ITC CONFERENCE GRANT SCIENTIFIC REPORT

This report is submitted for approval by the grantee to the MC Chair.

**Action number: CA15108**

**Conference title: 14<sup>th</sup> International Workshop “Dark Side of the Universe”**

**Conference start and end date: 25/06/2018 to 29/06/2018**

**Conference attendance start and end date: 25/06/2018 to 29/06/2018**

**Grantee name: Da Huang**

### ACTIVITIES DURING YOUR ATTENDANCE AT THIS CONFERENCE:

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(max.500 words)

Thanks to the ITC Conference Grant under the Action CA15108, I was able to take part in the stimulating International Workshop “Dark Side of the Universe” of this year. I enjoyed this journey very much.

First of all, I gave the talk with the title “Direct Detection of Exothermic Dark Matter with a Light Mediator” in the parallel session of DM direct detection on June 28<sup>th</sup>, 2018. In this talk, I summarized my recent investigations on the DM models with isospin violation, exothermic DM-nucleon scatterings and/or a light mediator effects, all of which aimed to reconcile the tension between the observed CDMS-Si anomalous events and other null experimental results, such as CDMSlite, SuperCDMS, LUX, PandaX-II, XENON1T, and PICO-60. We found that the combination of the upper limits from these recent experiments was so strong that none of the existing models could solve the problem. This negative result indicated that we need to think up some new ideas in the field. After my talk, I received several interesting questions and enlightening suggestions. One involved the possibility to combine the existing experimental data to strengthen the constraint further. Others concerned the possible modification of the results if I replaced the Standard Halo Model with the more general Halo models. They further suggested to use the newly-developed halo-independent method to redo the analysis. Due to the time limitation, I could not answer their questions and concerns immediately. But I do think their ideas are valuable for my following research.

Through the talks in this workshop, I was impressed much by the recent developments in the DM searches, either in the richness or in the depth. From the talk by Bradley J. Kavanagh, I learned that there were many new ways to distinguish the underlying DM mechanism, such as the spectral signatures, directional information, material responses, and daily modulations. I was also interested in the talk delivered by Marco Regis, whose proposed to use the multimessenger to detect DM particles in DM indirect searches, which included traditional cosmic rays, X-rays, antiprotons, neutrinos, and even gravitational waves. For the cosmological small scale problems, such as missing satellite problem, too-big-to-fail problem and cusp-vs-core problem, I learned from Dr. Arianna Di Cintio's talk that the baryon effect plays a important role in understanding these problems, either with or without DM self-interactions. Finally, I liked many new ideas involving the DM model buildings, such as the new connection between DM and the strong CP problem given by Lawrence Hall, the p-wave dominant Sommerfeld enhancement in solving the possible large annihilation rate in center of the Milky Ways by

Anirban Das, and the long-range interactions to solve cosmological small-scale problems by Marco Taoso.

Last but not least, during the workshop, I liked the sunshine, the fresh air, the clean water and the beautiful natural scenery in the Annecy very much, which made me relaxed even the workshop schedule was busy.

### **IMPACT ON YOUR RESEARCH AND FUTURE COLLABORATIONS (if applicable)**

(max.500 words)

I think that the participation of the 14<sup>th</sup> International Workshop "Dark Side of the Universe" (DSU) is important for my current researches.

Firstly, I have gained a lot with the discussion with Prof. Genevieve Belanger, who is one of the leading scientists in the DM searches. During my stay in the Laboratoire d'Annecy-le-Vieux de Physique Theorique, the host of this year's DSU, I gave a talk about my recent work on the freeze-in mechanism to generate the self-interacting DM particles, which was proposed to solve cosmological small-scale problems. It was pointed out by Prof. Belanger that my model suffered an additional constraints from star cooling rates by observing the horizontal branch stars, red giants and supernova 1987A, which I had not acknowledged before. Following the references provided by her, I found that these observations indeed gave the relevant constraints to our models, under which a considerable portion of the previously allowed parameter space was excluded. However, there was still a large parameter space which could give rise to large enough DM self-interactions while was not conflicted with the other experimental limits. Right now, I plan to update our paper in the arXiv version.

One of my purposes for this trip was to learn how to use the new version of the MicrOMEGAs code with Prof. Belanger, who was one of the main authors. Note that in the updated version of this year, the code was expanded with the function to calculate the freeze-in mechanism of DM productions. Thus, Prof. Belanger suggested me to use the new code to check the results of my self-interacting DM model. As a result, I found that the code was not capable in giving a reasonable calculation for the present model due to the large cancellation of the amplitudes, which resulted in a large error. I reported this problem to Prof. Belanger and Prof. Alexander Pukhov, another coder of the MicrOMEGAs, and my result was immediately confirmed by Prof. Pukhov during the meeting. After his return to Moscow, Prof. Pukhov solved this problem by adding some new functions, and I was honored to be the several first ones to use this new functions in order to check the code again. Right now, it seems OK. I was happy that my visit to LAPTh could help to improve the MicrOMEGAs code.

I was also benefitted from the discussion with other people met in the workshop. As mentioned before in the activity part, following the advice after my talk in the workshop, I plan to reanalyse the DM models in my previous studies with the halo-independent method, which can reflect the true situation by avoiding the bias of imposing a fixed DM velocity distributions.

In sum, my participation of the DSU workshop supported by ITC conference grant is very fruitful. What I gained is not only the knowledge of the current trend in the DM searches, but also the experience in the workshop and in LAPTh. I hope that I can have more chance and support to take part in the conferences out of Poland.