PandaX-I result sets a stringent limit for low-mass dark matter particles

Xiao-Gang He

Astrophysical and cosmological observations show that about 27% of the energy in our universe comes from dark matter (DM). What is DM is an outstanding puzzle in science in the 21st century. The weakly interacting massive particles (WIMPs) have been by far the favored candidate for DM, although they cannot be accommodated in the standard model of strong and electroweak interactions. DM theory asserts that our solar system is bathed in the DM halo of the Milky Way, with millions of WIMPs passing through our body every second. Interactions of DM with ordinary matter are exceedingly weak and may be detected by sensitive equipment through the energy deposited in a detector by elastic scattering of WIMPs with the nuclei of ordinary matter. There are many such direct-search experiments around the world, trying to catch the faint signals released in the form of photons, electrons or heat using different technologies. Several experiments, such as the Dark Matter/Large Sodium Iodide Bulk for Rare Processes experiment in Italy, the Coherent Germanium Neutrino Technology and Cryogenic Dark Matter Search (CDMS) experiments in the USA and the German-led Cryogenic Rare Event Search with Superconducting Thermometers experiment, have in recent years reported positive signals, which could be interpreted as light WIMPs. The first results published in *Sci China Phys Mech Astron* this year by the PandaX collaboration, however, downgrade these claims [1].

The PandaX (Particle AND Astrophysical Xenon Detector) collaboration is an international team of about 40 scientists led by Professor Xiangdong Ji from Shanghai Jiao Tong University (also affiliated with the University of Maryland). This is the first large-scale xenon DM search experiment carried out in the newly established China Jinping Underground Laboratory (CJPL) in Sichuan, China. CJPL is among the deepest underground laboratories in the world, and being well shielded from the cosmic ray background. Xenon is a noble gas, which becomes liquid at about 110° below zero Celsius. The current experiment uses about 120 kg of liquid xenon as the active target for WIMPs. The detector employs a technology called the dual-phase xenon time-projection chamber (TPC), enabling a 3D reconstruction of the events. This technology was shown to be one of the more promising technologies based on the similar 100 kg XENON DM project (XENON100) and the Large Underground Xenon experiments. It now offers improved detection sensitivity over a wide range of DM mass by two orders of magnitude compared with other experiments.

The first stage of PandaX operations, PandaX-I, intends to examine the curious signals of WIMPs in the low-mass region reported by previous experiments. Its detector is a pancake-shaped TPC designed for high photon-collection efficiency. PandaX-I’s first results are based on the data collected in 17.4 live days, with more than 4 million raw events recorded. After removing the low-quality events and narrowing the energy search window to the regions of interest, 46 events are seen in the central fiducial volume with 37 kg of liquid xenon. These events are consistent with signals from the background radiation, the paper reports. Without candidate WIMP DM events, PandaX-I sets a stringent limit for low-mass DM particles and effectively rules out the interpretation of positive experimental results previously reported.

Together with the results reported by the China Dark matter Experiment led by scientists at Tsinghua University (also at CJPL) and the SuperCDMS experiments in the USA, PandaX has set one of the best limits for WIMP DM with low mass, as can be seen from the Fig. 1. PandaX’s first result demonstrates that China has become a competitive player in the search for DM, a *Science News* article commented. ‘It is very exciting to see that our detector has such a capability’, said Jianglai Liu, who led the data analysis and also contributed significantly to the detector construction. Indeed, the PandaX collaboration has since collected more than 75 days of data, which will have five times better detection sensitivity. The PandaX experiment is also upgrading its detector mass to 500 kg, and will commence operations in 2015. Meanwhile, XENON1T, a similar experiment but with a 1.5-ton detector mass, developed by a US-Europe collaboration...
at the Gran Sasso laboratory in Italy, is commissioned to begin in late 2015. The global race to detect DM is becoming tighter than ever.

Xiao-Gang He
Department of Physics and Astronomy, Shanghai Jiao Tong University, China
E-mail: hexg@sjtu.edu.cn

REFERENCE
1. Xiao, MJ, Xiao, X and Zhao, L et al. Sci China Phys Mech Astron 2014; 57: 2024–30.
doi: 10.1093/nsr/nwv008
Advance access publication 7 February 2015

PLANT & ANIMAL SCIENCE

Bitter but tasty cucumber

Xiao-Ya Chen

Plant natural products consisting mainly of phenolic compounds, alkaloids and terpenoids, are valuable for both plants and humans. Recently a breakthrough has been made in elucidation of biosynthesis of cucurbitacins [1], a class of highly oxygenated tetracyclic triterpenoids present in the family Cucurbitaceae, which confer unpleasant bitter taste to help the plant to wade off herbivores and are exploited by humans in form of traditional herbal medicines for their anti-inflammatory, hepatoprotective and potential antitumor properties [2,3]. Widely consumed as vegetables and fruits, the cultivated non-bitter cucurbits, e.g. cucumber, melon and watermelon, are domesticated from their extremely bitter ancestors thousands of years ago. However, some of domesticated cultivars would turn bitter when they were grown under stress, e.g. drought or low temperature, seriously affecting their quality and marketability. The underlying mechanism remains largely unknown. Recently, several studies have shown that plant secondary metabolites are biosynthesized by clustering of functionally related enzymes [4]. However, whether similar triterpenoid biosynthetic cluster also exists in cucurbits and more importantly, how to regulate the gene clusters in plants are unknown.

After the initiation of cucumber genome project, Sanwen Huang and colleagues have de novo sequenced the genome of cucumber and draw the first cucumber variation map [5,6]. By integrating these big genomic data and multiple research tools, they cloned the cucumber bitterness gene (Bi), which participates the first committed step of cucurbitacin C (Cuc C) biosynthesis. Identification of two non-bitter mutants and analysis of cucumber variation map lead to the discovery of Bl (bitter leaf) and Bt (bitter fruit), two bHLH