赵忠尧博士后面试答辩

李 楠

合作导师：焦毅

中国科学院高能物理研究所

2021年6月5日

个人简历

学习经历

- 2008 - 2012 北京工业大学 应用物理 学士
- 2012 - 2015 北京工业大学 理论物理 硕士
- 2016 - 2020 中科院理论所 理论物理 博士

研究生期间主要研究方向为暗物质间接探测，特别是通过宇宙线中的反物质粒子来探测粒子暗物质。

2020年11月进入高能所加速器中心做博士后，从事加速器物理研究，合作导师为焦毅研究员。主要研究方向为高能同步辐射光源(HEPS)相关的物理问题。

以往工作概况

- "Baryon asymmetries in a natural inflation model", Nan Li and Ding-fang Zeng, PRD 90 (2014) 123542.
- "Prospects of detecting dark matter through cosmic-ray antihelium with the antiproton constraints", Nan Li *et al*, JCAP06 (2019) 004.
- "Cosmic-ray antinuclei as messengers of new physics: status and outlook for the new decade", P. von Doetinchem *et al*, JCAP 08 (2020) 035.
- "High energy window for probing dark matter with cosmic-ray antideuterium and antihelium", Nan Li *et al*, CPC 45 (2021) 065102.
- "Implications of a possible TeV break in the cosmic-ray electron and positron flux", accepted by PRD.

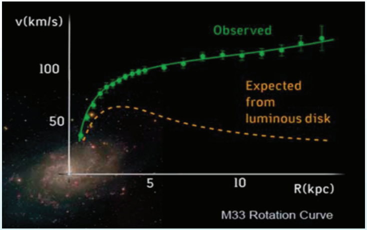
近期工作概况

进入高能所加速器中心以来完成三篇会议论文，两篇技术文档:

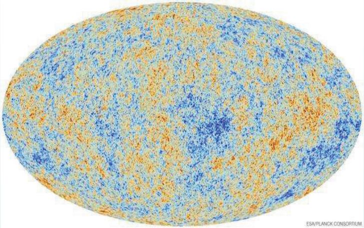
- “Comparison simulation results of the collimator aperture in the HEPS storage ring”, Conf. IPAC 21, 2021, paper MOPAB061.
- “Impact of Different Models of Combined-function Dipoles on the HEPS Parameters”, Conf. IPAC 21, 2021, paper MOPAB089.
- “Progress of lattice design and physics studies on the High Energy Photon Source”, Conf. IPAC 21, 2021, paper MOPAB053.
- “基于lattice V3.1 的准直器孔径模拟”, HEPS Technical Note, HEPS-AC-AP-TN-2021-008-V0
- “BD铁不同硬边界模型对储存环参数影响分析”, HEPS Technical Note, HEPS-AC-AP-TN-2020-025-V0

Dark Matter

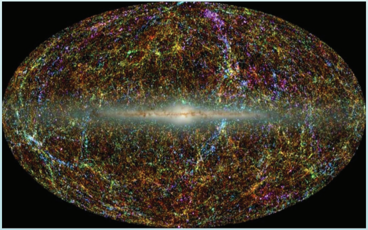
Evidences of the dark matter:



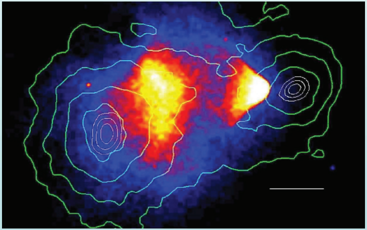
Rotation Curve



CMB



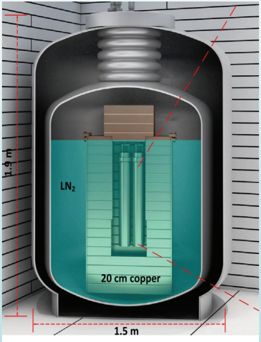
Large Scale Structure



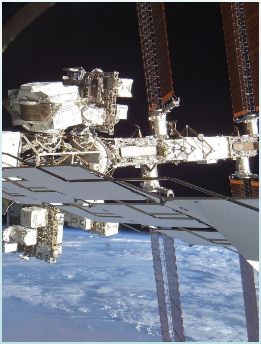
Bullet Cluster

Dark Matter

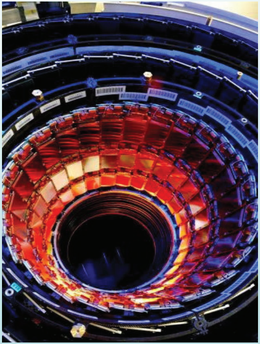
Although the existence of Dark Matter (DM) are supported by various gravitational observations, the particle nature of DM is still largely unknown.



Direct



Indirect



Collider

Anti-nuclei in cosmic rays

Anti-nuclei in CR are important probes in Dark Matter indirect detection.

- The high production threshold boosts the secondary productions to high kinetic energies, leaving a high signal to background ratio in low energy regions.
- The production of anti-nuclei are highly correlated with anti-protons, the uncertainties of CR anti-nuclei can be well constrained by the CR anti-proton observations.

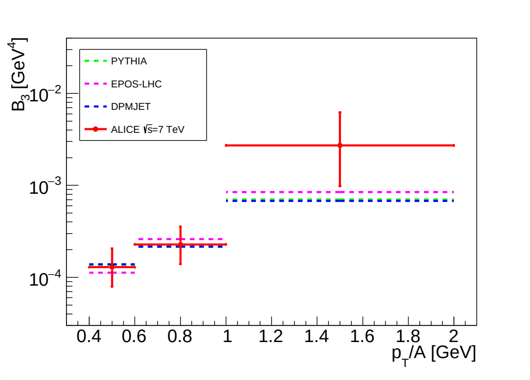
coalescence model

Nucleons combine into a nucleus if the relative four-momenta of proper sets of nucleons is less than the coalescence momentum p_0.

Fitting the ALICE data

CR $^3\overline{\text{He}}$ is a good probe. The ALICE group released the only $^3\overline{\text{He}}$ data in pp collisions ,at $\sqrt{s} = 7$ TeV.

MC generators: **PYTHIA, EPOS-LHC, DPMJET**



The p_T dependence are reproduced.

The propagation of anti-nuclei in CR

The diffusion equation

$$\frac{\partial \psi}{\partial t} = q(\vec{r}, p) + \vec{\nabla} \cdot (D_{xx} \vec{\nabla} \psi - \vec{V}_c \psi) + \frac{\partial}{\partial p} p^2 D_{pp} \frac{\partial}{\partial p} \frac{1}{p^2} \psi$$
$$- \frac{\partial}{\partial p} \left[\dot{p} \psi - \frac{p}{3} (\vec{\nabla} \cdot \vec{V}_c) \psi \right] - \frac{1}{\tau_f} \psi - \frac{1}{\tau_r} \psi$$

The equation is solved by the **GALPROP** v54 code.

Three propagation models:

A global Bayesian fitting to the AMS-02 B/C ratio and proton flux

Model	r_h(kpc)	z_h(kpc)	D_0	R_0(GV)	δ_1/δ_2	V_a(km/s)	R_{ps}(GV)	γ_{p1}/γ_{p2}
MIN	20	1.8	3.53	4.0	0.3/0.3	42.7	10.0	1.75/2.44
MED	20	3.2	6.50	4.0	0.29/0.29	44.8	10.0	1.79/2.45
MAX	20	6.0	10.6	4.0	0.29/0.29	43.4	10.0	1.81/2.46

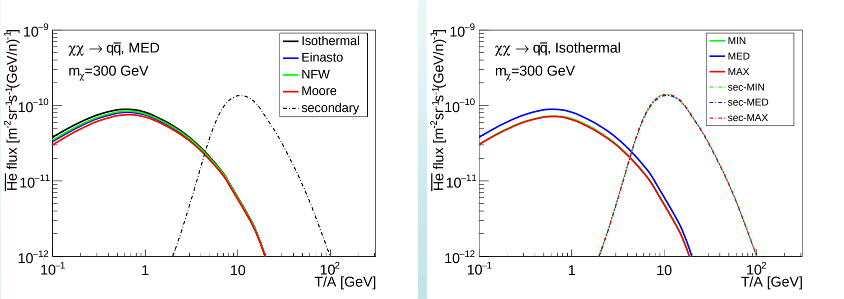
H.-B. Jin et al., JCAP 09 (2015) 049

The flux of $^3\overline{\mathrm{He}}$

An advantage of constraining $^3\overline{\mathrm{He}}$ with $\bar{p}$: greatly reducing the uncertainties.

Fixed $<\sigma v>$: propagation models $\mathcal{O}(10)$ DM profiles $\mathcal{O}(10)$

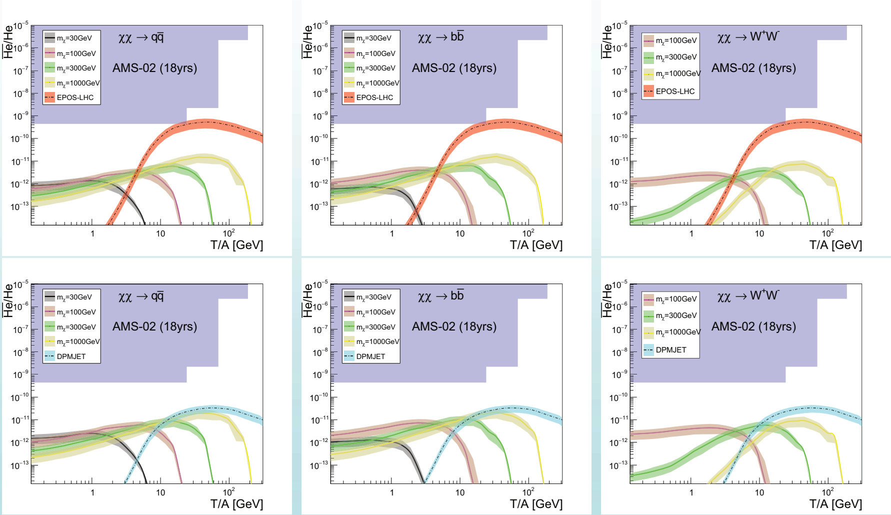
$\bar{p}$ constrained $<\sigma v>$: propagation models 30% DM profiles 30%



$Left$) Differences between the DM profiles. $Right$) Differences between the propagation models.

The detecting prospects on AMS-02

Propagation model: MED   DM profile: Isothermal



工作计划

高能同步辐射光源(HEPS)的相关问题:

- 磁铁边缘场效应对束流参数的影响及相应的校正
- 储存环早期调束的模拟
- 自动调束的算法及软件的编写
- 机器学习在加速器物理中的应用

Thank you !