Antideuteron 2019 - University of California, Los Angeles

Report of Contributions

Contribution ID: **1** Type: **oral**

Alternative Coalescence Model

Thursday, March 28, 2019 2:40 PM (20 minutes)

The production of light clusters of (anti-) nuclei like (anti-) deuteron, (anti-) helium or (anti-) trition is usually described by coalescence models. In e^+e^- collisions and dark matter annihilations, one imposes typically the coalescence condition in momentum space, including often the two-particle correlations provided by Monte Carlo simulations on an event-by-event basis. In contrast, in nuclear collisions one often neglects two-particle correlations in momentum space but includes constraints on the spatial emission volume of the event. Here we propose a coalescence model in phase-space based on the Wigner function representation of the nucleons and nuclei which includes both constraints on the momentum and the space variables of the event. We compare the predictions of this model with experimental data from e^+e^- collisions at LEP and pp collisions at LHC and find in general good agreement with the data. We comment also briefly on the resulting detection prospect of AMS-02 for anti-nuclei.

Primary authors: Mr TJEMSLAND, Jonas (NTNU); Prof. KACHELRIESS, Michael; Dr OSTAPCHENKO, Sergey

Presenter: Mr TJEMSLAND, Jonas (NTNU)

Contribution ID: **4** Type: **oral**

Propagation and Absorption of Antideuterons and Antiprotons

Friday, March 29, 2019 9:45 AM (30 minutes)

The search for low-energy cosmic anti-ions may reveal exotic production processes—such as dark-matter annihilation—because of the low production rate of such ions through inelastic scattering of cosmic-ray protons with the interstellar medium. However, a precise prediction of the expected antiparticle fluxes is challenging, since their production cross sections are not well known; they are strongly deflected by the magnetic fields of the Sun and Earth; and can interact with interstellar matter. These effects significantly modify the fluxes and spectra we can observe near Earth.
We present our studies of the spatial and temporal variations of antiproton and antideuteron fluxes using different propagation and reaction models, including estimations of expected spectra for different space-based experiments. To better understand the annihilation processes, we investigate the cross sections implemented in different versions of the GEANT simulation toolkit. In this context, we study the feasibility of a measurement of the annihilation cross sections of antiprotons and antideuterons with the ALICE detector at the CERN's Large Hadron Collider—either by measuring the antiparticle-to-particle ratios or by directly detecting annihilation vertices within the detector.

Primary authors: FABBIETTI, Laura (Technische Universität München); PÖSCHL, Thomas (Technical University of Munich); SERKSNYTE, Laura

Presenter: PÖSCHL, Thomas (Technical University of Munich)

Contribution ID: **5** Type: **oral**

New estimation of the secondary antideuteron cosmic-ray flux

Thursday, March 28, 2019 4:30 PM (30 minutes)

A new study about the production of antideuterons in high-energy cosmic-ray collisions is presented in this work. Antideuteron production cross-section is obtained through the coalescence model, which is simulated using an afterburner and the Monte Carlo generator EPOS-LHC. Coalescence model key parameter (p_0) is calculated from the comparison of simulation to updated collider data, including ALICE-LHC results. Antideuteron propagation in the Galaxy is evaluated employing GALPROP. The resulting antideuteron flux shows a larger magnitude compared to previous studies and a slightly different shape in the energy distribution as a consequence of the coalescence parameter (p_0) energy dependence.

Primary author: GOMEZ CORAL, Diego (Instituto de Física, UNAM)

Presenter: GOMEZ CORAL, Diego (Instituto de Física, UNAM)

Contribution ID: **6** Type: **oral**

Search for Cosmic-Ray Antideuterons with BESS-Polar II

Wednesday, March 27, 2019 1:45 PM (30 minutes)

High-precision measurement of the cosmic-ray antiproton spectrum and sensitive search for cosmological antihelium has been published using the data from BESS-Polar II (Balloon-borne Experiment with a Superconducting Spectrometer) flight in 2007/2008 for core study of the early Universe using elementary particle measurements.
The most sensitive antideuteron search reported used the data obtained by BESS97, BESS98, BESS99, and BESS00, which include the solar minimum period in 1997. We performed a search for antideuterons with unprecedented sensitivity using BESS-Polar II data that is more than ten times the statistics of BESS97 in near solar minimum conditions. The search for antideuteron probe possible exotic sources, such as dark-matter candidates.

Primary author: SAKAI, Kenichi (NASA/GSFC/CRESST/UMBC)

Presenter: SAKAI, Kenichi (NASA/GSFC/CRESST/UMBC)

Contribution ID: **7** Type: **oral**

Status of the Anti Deuteron Helium Detector (ADHD) project

Thursday, March 28, 2019 10:15 AM (20 minutes)

The observation of GeV and sub-Gev anti-deuteron in the cosmic ray flux, could be a very strong signature of dark matter annihilation in our galaxy.
Our project, called ADHD (Anti Deuteron Helium Detector) aims to study the signatures offered by an high pressure He target where anti-deuterons can be captured by He atoms.
The exotic He atoms produced by stopping anti-protons/anti-deuterons in the gas are lasting for tens of microseconds before the annihilation.
This meta-stability is an unique (and well measured) feature for the He target that is not expected/observed for other target nuclei.
The scintillation properties of gaseous He allow for a prompt signal of a charge particle entering the detector active volume.
In the case of anti-proton or anti-deuteron the characteristic delayed annihilation signal produces a distinctive signature to identify the antimatter nature of the stopping particle.
The amplitude and the topological features of the delayed signal makes possible to separate anti-deuterons from anti-protons.
Perspectives for a possible space borne detector and the status of the characterization of a 200 Bar scintillating He detector prototype in the INFN-TIFPA laboratory will be discussed.

Primary authors: Dr DIMICCOLI, Francesco (INFN TIFPA, I-38123, Trento, Italy); NOZZOLI, Francesco (Istituto Nazionale Fisica Nucleare INFN-TIFPA); Dr ZUCCON, Paolo (Università di Trento, I-38123, Trento, Italy)

Presenter: NOZZOLI, Francesco (Istituto Nazionale Fisica Nucleare INFN-TIFPA)

Contribution ID: **8** Type: **oral**

Measuring cross sections for anti-p and anti-d production with COMPASS++/AMBER

Friday, March 29, 2019 11:15 AM (30 minutes)

The abundance of cosmic-ray anti-matter components as a function of the energy, is one of the most promising ways to spot signatures of dark matter annihilation in our galaxy.
The challenge in this line of research resides however in the ability to predict the natural, i.e. not from dark matter, abundance of these species; namely positrons, anti-protons and anti-deuterons. These particles are produced by the interactions of the most abundant cosmic rays components with the Inter Stellar Medium, mostly protons and He nuclei. Especially for anti-protons and anti-deuterons large part of the expectation uncertainties comes from the limited knowledge of the anti-proton(deuteron) production cross section in the p-p and p-He interactions.
We setup a special program within the COMPASS++/AMBER collaboration to accurately measure these cross sections. I will report about our project and about how these measurements will improve the global sensitivity to dark matter signals.
I will also briefly report on a preliminary measurement of the "p-p to anti-p + X"cross section using past data of the COMPASS experiment.

Primary author: Dr ZUCCON, Paolo (Università di Trento, I-38123, Trento, Italy)

Presenter: Dr ZUCCON, Paolo (Università di Trento, I-38123, Trento, Italy)

Contribution ID: **9** Type: **oral**

Cosmic rays, antihelium, and an old navy spotlight

Wednesday, March 27, 2019 4:05 PM (30 minutes)

Cosmic-ray anti-deuterium and anti-helium have long been suggested as probes of dark matter, as their secondary astrophysical production was thought extremely scarce. But the prediction of the secondary anti-nuclei flux remains uncertain, as the astrophysical production is dominated by pp collisions, where laboratory cross section data is severely lacking. I will discuss attempts at tackling this problem using a scaling relation between the coalescence yield and the volume of the hadronic emission region; the latter can be probed by Hanbury Brown-Twiss analyses. The scaling relation shows consistency with a multitude of AA and pA collision data. Using the scaling relation, the predicted astrophysical anti-helium flux is orders of magnitude higher than most previous estimates, and could be within reach by AMS-2.

Primary author: NG, Kenny Chun Yu (Weizmann Institute of Science)

Co-authors: BLUM, Kfir; SATO, Ryosuke; TAKIMOTO, Masahiro

Presenter: NG, Kenny Chun Yu (Weizmann Institute of Science)

Contribution ID: **10** Type: **oral**

New developments in astrophysics of cosmic rays

Wednesday, March 27, 2019 9:15 AM (30 minutes)

The last decade brought spectacular advances in the astrophysics of cosmic rays and gamma-ray astronomy. These observations pose a considerable challenge to conventional astrophysics thus leaving an ample discovery space for new phenomena. Understanding the conventional astrophysical backgrounds is vital in moving to the new territory. In my talk I will discuss recent developments in astrophysics of cosmic rays and how well we understand the conventional backgrounds.

Primary author: MOSKALENKO, Igor (Stanford University)

Presenter: MOSKALENKO, Igor (Stanford University)

Contribution ID: **11** Type: **oral**

Solar modulation of cosmic rays with the PAMELA experiment: an important study for indirect dark matter detection

Wednesday, March 27, 2019 2:15 PM (30 minutes)

The satellite-borne PAMELA experiment was launched on the 15th June
2006 from the Baikonur cosmodrome. Until January 2016 PAMELA made high-precision measurements of the charged
component of cosmic-rays over a wide energy range. Because of its long-duration operation, PAMELA represents an ideal detector for cosmic-ray solar modulation studies.

The PAMELA collaboration published time-dependent proton, helium and electron spectra as well as the positron to electron ratio over ten years of data taking.
These results were extensively used to fine-tune a state of the art 3D numerical model for cosmic rays propagation trough the Heliosphere. This numerical model takes into account all the physicsl
processes of propagation including the charge-sign dependence.

A precise knowledge of the amount of solar modulation on the astrophysical background of low energy antiparticle spectra is fundamental in order to search for an
excess due to e.g. dark matter annihilation or decay.

Here the main results of the PAMELA experiment on solar modulation are presented togheter with a brief description of the 3D numerical propagation model.
The global solar modulation effect as well as the associated uncertainties on the low energy antimatter
component of cosmic rays will be also discussed in the framework of indirect dark matter detection.

Primary author: MUNINI, Riccardo (INFN - Trieste)

Presenter: MUNINI, Riccardo (INFN - Trieste)

Contribution ID: **12** Type: **oral**

Antideuterons at LHCb

Friday, March 29, 2019 10:45 AM (30 minutes)

In this talk, work towards a measurement of the (anti)deuteron cross-section in high energy proton-proton collisions using the LHCb detector will be presented. This measurement will help to constrain (anti)deuteron production models, and will pave the way for measurements of (anti)deuterons in b-hadron decays and pHe collisions.

LHCb is a single-arm forward spectrometer at the LHC, optimised to precisely measure decays of heavy-flavour hadrons. Ring imaging Cherenkov detectors are used to distinguish between charged particle species, such as pions, kaons, protons, and most recently, deuterons. Predictions of the (anti)deuteron yield, using an afterburner on top of standard LHCb Monte Carlo, will be shown, as well as neural net variables used to maximise separation between (anti)deuterons and other particles.

Primary author: BAKER, Sophie (Imperial College London)

Presenter: BAKER, Sophie (Imperial College London)

Contribution ID: **13** Type: **oral**

Prospects of detecting dark matter through cosmic-ray antihelium with the antiproton constraints

Thursday, March 28, 2019 11:35 AM (30 minutes)

Cosmic-ray (CR) antihelium can be an important observable for dark matter (DM) indirect searches due to extremely low secondary backgrounds towards low energies. In most DM models, the predicted CR antihelium flux is strongly correlated with that of CR antiprotons. Thus the upper limits on the DM annihilation cross sections from the current antiproton data can be used to place stringent limits on the maximal antihelium flux for the same model. Making use of the latest AMS-02 data on the antiproton to proton flux ratio and the coalescence model for the anti-nuclei formation, we obtain the maximal antihelium flux for typical DM annihilation final states such as $q\bar{q}$, $b\bar{b}$ and W^+W^-. The results are insensitive to the choices of DM density profiles and CR propagation models, but significantly dependent on the parameter of the coalescence momentum of the coalescence model. The prospects of detecting antihelium for the AMS-02 experiment is discussed. We show that with very optimistic assumptions on detection efficiency, acceptance and coalescence momentum, CR antihelium is within the reach of the AMS-02 experiment. The events which can be detected by AMS-02 are likely to have kinetic energy T⊠30 GeV and dominantly arise from secondary backgrounds rather than DM interactions.

Primary authors: Dr LI, Nan (ITP,CAS); Dr WEI, Chun-Cheng (ITP,CAS); Prof. WU, Yue-Liang (ITP.CAS); Prof. ZHOU, Yu-Feng (ITP.CAS)

Presenter: Dr LI, Nan (ITP,CAS)

Contribution ID: **14** Type: **oral**

Prospects to find cosmic-ray antinuclei and the impact of cross section uncertainties

Thursday, March 28, 2019 2:00 PM (20 minutes)

The search and measurement of cosmic-ray antimatter provides a great potential to study annihilating dark matter in our Galaxy.Previous analyzes of the antiproton spectrum determined by the AMS-02 experiment revealed a potential hint for a DM signal with a mass around 70 GeV and a thermal annihilation cross section. This putative signal is, however, affected by several systematic uncertainties such that its indisputable validation or exclusion is a non-trivial task. One important source of uncertainty is the production cross section of secondary antiprotons. I will discuss the impact of the cross section uncertainties on the search of dark matter and the potential signal.The most direct but complementary way to test the dark matter interpretation of the antiproton spectrum would be the observation of low-energy antinuclei in cosmic rays. The corresponding antideuteron signal is within GAPS and AMS-02 sensitivity, while the antihelium signal stays below AMS-02 sensitivity. If, more conservatively, the potential dark matter signal is considered as an upper limit on the annihilation cross section of DM,the corresponding antideuterons and antihelium signal indicate the highest possible fluxes compatible with the latest antiproton data. I will discuss the chances to detect the antimatter fluxes, in particular, focussing on the systematic uncertainties due to cross sections and the coalescence process.

Primary author: KORSMEIER, Michael (University of Turin)

Co-authors: DONATO, Fiorenza (Torino University); FORNENGO, Nicolao (University of Torino and INFN)

Presenter: KORSMEIER, Michael (University of Turin)

Contribution ID: **15** Type: **oral**

Dark Matter and the Cosmic Ray Antiproton Spectrum

Wednesday, March 27, 2019 11:15 AM (30 minutes)

The cosmic-ray antiproton spectrum as measured by AMS-02 contains an excess at 10-20 GeV relative to the predictions of standard transport models. I will discuss the systematic uncertainties associated with this signal and the implications of the excess for annihilating dark matter.

Primary author: HOOPER, Dan (Fermilab/University of Chicago)

Presenter: HOOPER, Dan (Fermilab/University of Chicago)

Contribution ID: **16** Type: **oral**

Where do AMS-02 anti-helium events come from?

Wednesday, March 27, 2019 5:05 PM (30 minutes)

In this talk, I will discuss consequences of the potential detection of anti-helium-3 and -4 events by AMS-02 and in particular the very surprising isotopic ratio in cosmic rays that it would indicate. After showing that spallation from primary hydrogen and helium nuclei onto the ISM cannot account for the measured fluxes, I will argue that dark matter annihilation or decay face similar difficulties in explaining these events. I will then entertain the possibility that these events originate from anti-matter-dominated regions in the form of anti-clouds or anti-stars. Starting with the case of anti-clouds, I will show how the isotopic ratio of anti-helium nuclei might suggest that BBN has happened in an inhomogeneous manner, resulting in anti-regions with a anti-baryon-to-photon ratio η-bar ⊠ 0.001η. However, I will show that a variety of observations strongly constrain this scenario, and in particular, would require the anti-clouds to be almost free of normal matter. I will finally discuss an alternative scenario where anti-domains are dominated by surviving anti-stars and suggest that part of the unidentified sources in the 3FGL catalog can originate from anti-clouds or anti-stars.

Primary authors: POULIN, Vivian (LUPM, Montpellier, France); SALATI, Pierre (Laboratoire d'Annecy-le-Vieux de Physique Théorique LAPTh)

Presenter: POULIN, Vivian (LUPM, Montpellier, France)

Contribution ID: **17** Type: **oral**

Hadronic Cosmic Rays: Towards the Precision Era

Thursday, March 28, 2019 12:05 PM (30 minutes)

Cosmic ray experiments are reaching the sensitivity where they can realistically probe the annihilation of thermal WIMPs. Due to the tiny experimental errors, uncertainties in the astrophysical backgrounds have become the most
limiting factor for dark matter detection. I will use the combination of antiproton, boron to carbon and positron data in order to systematically reduce uncertainties related to cosmic ray propagation. Furthermore, I will employ a wide collection of accelerator data to improve the astrophysical source term for antiprotons, and point out implications for antideuteron formation. I will discuss results from a spectral search for dark matter annihilation in the AMS-02 antiproton data and comment on prospects for dark matter detection with antinuclei.

Primary author: WINKLER, Martin (Stockholm University)

Presenter: WINKLER, Martin (Stockholm University)

Contribution ID: **18** Type: **oral**

Antinuclei in Primary Cosmic Rays with the Alpha Magnetic Spectrometer on the International Space Station

Wednesday, March 27, 2019 3:05 PM (30 minutes)

The search for antideuterons and antihelium events primary cosmic rays with the data collected in the first 7 years of AMS-02 data collection will be discussed.

Primary author: OLIVA, Alberto (CIEMAT)

Presenter: OLIVA, Alberto (CIEMAT)

Contribution ID: **19** Type: **oral**

Production and Acceleration of Antinuclei in Supernova Shockwaves

Thursday, March 28, 2019 2:20 PM (20 minutes)

We compute the energy spectra of antideuterons and antihelium in cosmic rays in a scenario where hadronic interactions inside supernova remnants can produce a diffusively shock-accelerated "source component"of secondary antinuclei along with their standard secondary component expected from cosmic ray collisions in the interstellar gas.

Primary authors: OLIVA, Alberto (CIEMAT); TOMASSETTI, Nicola (INFN and University of Perugia)

Presenter: OLIVA, Alberto (CIEMAT)

Contribution ID: **20** Type: **oral**

Updated secondary anti-helium cosmic ray fluxes

Wednesday, March 27, 2019 4:35 PM (30 minutes)

AMS-02 might have discovered in its data a few anti-helium events. These are presumably ordinary cosmic rays that have been mis-reconstructed, owing to a very rare pattern of their tracks in the detector. To illustrate how problematic these anti-helium events would be, should they be confirmed, we have updated the calculation of the anti-helium cosmic ray fluxes at the Earth from secondary origin. We show that spallation from primary hydrogen and helium nuclei onto the interstellar medium yields an anti-He-3 flux typically one to two orders of magnitude below the sensitivity of AMS-02 after 5 years, and an anti-He-4 flux roughly 5 orders of magnitude below AMS sensitivity. I will present how these secondary anti-helium fluxes have been derived and also comment upon the difficulties of the annihilating dark matter explanation.

Primary authors: SALATI, Pierre (Laboratoire d'Annecy-le-Vieux de Physique Théorique LAPTh); POULIN, Vivian (LUPM, Montpellier, France)

Presenter: SALATI, Pierre (Laboratoire d'Annecy-le-Vieux de Physique Théorique LAPTh)

Contribution ID: **21** Type: **oral**

Scrutinizing the evidence for dark matter in cosmic-ray antiprotons

Wednesday, March 27, 2019 11:45 AM (20 minutes)

During the last decade, the space-based experiment AMS-02 has drastically reduced the measurement uncertainty of primary and secondary cosmic-ray fluxes. Therefore, global fits of these fluxes provide great potential to study comic-ray propagation models and search for exotic sources of antimatter such as annihilating dark matter. Previous studies of AMS-02 antiprotons revealed a possible hint for a dark matter signal which, intriguing, would be in agreement with the dark matter interpretation of the gamma-ray excess at the Galactic center. On the other hand, systematic uncertainties in the theoretical description of cosmic rays become gradually more relevant as the data uncertainties are reduced. I will discuss two important sources of uncertainties in order to test the robustness of the putative dark matter signal: the antiproton production cross-sections needed to calculate the source spectra of secondary antiprotons and potential correlations in the experimental data, so far not provided by the AMS-02 collaboration. In particular, to investigate the impact of cross-section uncertainties I will present the results of two different methods. In the first method, the uncertainties are taken into account by including a covariance matrix determined from nuclear cross-section measurements. The alternative approach is to perform a joint fit, simultaneously to cosmic-ray and cross-section data. I will show that the cross-section uncertainties have a small effect on the cosmic-ray fits. The inclusion of potential correlations in the data could have a much larger impact. I will discuss a method to determine and include possible benchmark models for the correlations in a data-driven approach.

Primary author: KORSMEIER, Michael (University of Turin)

Co-authors: CUOCO, Alessandro; HEISIG, Jan; KLAMT, Lukas; Prof. KRÄMER, Michael

Presenter: KORSMEIER, Michael (University of Turin)

Contribution ID: **22** Type: **oral**

Dark matter searches using cosmic ray antiprotons

Wednesday, March 27, 2019 12:05 PM (20 minutes)

The cosmic-ray (CR) antiprotons, which primarily come from the inelastic collisions between the CR protons (and helium) and the interstellar medium, are effective to constrain the dark matter (DM) models.
The background parameters about the propagation, source injection, and solar modulation are based on results inferred from newest AMS-02 and Voyager data, and on the cross section of antiproton production from new collider data. We use a Bayesian approach to consider the uncertainties of both the background and the DM annihilation components of antiprotons. We find that including a component of antiprotons from DM annihilation can improve the fit to the AMS-02 antiproton data considerably.
Furthermore, based on the effective field theory approach, we also investigate the compatibility of the DM interpretation of the AMS-02 antiproton excess and the null results from direct detection experiments, LUX, PandaX-II, and XENON1T.

Primary author: Dr CUI, Mingyang (Purple Mountain Observatory)

Co-authors: Prof. YUAN, Qiang (Purple Mountain Observatory); Prof. FAN, Yizhong (Purple Mountain Observatory); Prof. TSAI, Yue-Lin Sming (Institute of Physics, Academia Sinica); Dr PAN, Xu (Purple Mountain Observatory)

Presenter: Dr CUI, Mingyang (Purple Mountain Observatory)

Contribution ID: **23** Type: **not specified**

Searching for Dark Photon Dark Matter with Cosmic Ray Antideuterons

Wednesday, March 27, 2019 5:35 PM (20 minutes)

Cosmic ray antideuterons have received attention as a rare event probe of dark matter (DM) physics due to their low astrophysical background. As conventional thermal relic WIMP models have become increasingly constrained by direct detection, these indirect channels become essential as they access the "hidden sector" DM interactions that direct detection is blind to.

We consider models of dark photon dark matter, thermal relic DM with a massive dark photon kinetically mixed with the Standard Model photon. We find that ~ 30 GeV DM candidates are poorly constrained by CMB and anti-proton indirect detection bounds. Moreover direct detection sensitivities to these models are suppressed by the mixing parameter if annhilation into dark photons is kinematically allowed. This makes anti-deuteron annihilation signatues ideal places to search. We investigate the expected anti-deuteron flux on Earth for a range of propagation models, and report prospects of detection by the future GAPS experiment.

Primary authors: XU, Weishuang; Prof. RANDALL, Lisa (Harvard University)

Presenter: XU, Weishuang

Contribution ID: **24** Type: **oral**

Galactic cosmic-ray physics after AMS-02

Wednesday, March 27, 2019 9:45 AM (30 minutes)

The current generation of cosmic-ray (CR) experiments in the GeV-TeV range has reached an unprecedented level of precision, unveiling fine-details of the energy spectra. The interpretation of these measurements could require a profound revision of the widely accepted paradigm of CR acceleration at galactic sources and/or of their transport through the interstellar environments.
In my talk I will discuss how AMS02 data have severely tested standard approaches to model galactic propagation in terms of scale-free diffusion and advection and I will then highlight a number of hypotheses for the origin of these new features.

Primary author: EVOLI, Carmelo (Gran Sasso Science Institute)

Presenter: EVOLI, Carmelo (Gran Sasso Science Institute)

Contribution ID: **25** Type: **oral**

Recent Developments in Geant4 Physics

Thursday, March 28, 2019 4:00 PM (30 minutes)

Since the last Antideuteron workshop there have been many improvements in the simulation of physics processes in Geant4. This talk will cover medium and high energy hadronic and electromagnetic physics models implemented or improved since then, with a focus on those of most importance for antideuteron detection. Topics will include improved cascade and QCD string models, as well as multiple scattering, pair production and bremsstrahlung.

Primary author: WRIGHT, Dennis (SLAC)

Presenter: WRIGHT, Dennis (SLAC)

Contribution ID: **26** Type: **oral**

(Anti)Nuclei production at the LHC with ALICE

Friday, March 29, 2019 9:15 AM (30 minutes)

The high energy pp, p-Pb, and Pb-Pb collisions at the LHC offer a unique tool to study the production of light (anti-)nuclei.
Thanks to its excellent particle identification and tracking capabilities, the ALICE detector allows for the measurement of deuterons, tritons, ^{3}He, ^{4}He and their corresponding anti-nuclei in a wide momentum range.
Results on the production yields of light nuclei and anti-nuclei in pp, p-Pb, and Pb-Pb collisions at energies going from 5 TeV to 13 TeV will be presented.
The experimental results will be compared with the predictions of the statistical (thermal) model and the baryon coalescence approach to provide insight in the production mechanisms of light (anti)-nuclei in ultra-relativistic collisions.

Primary author: LEA, Ramona (University and INFN (Trieste))

Presenter: LEA, Ramona (University and INFN (Trieste))

Contribution ID: **27** Type: **oral**

Deuteron identification with the AMS-02 RICH detector

Wednesday, March 27, 2019 2:45 PM (20 minutes)

The Alpha Magnetic Spectrometer (AMS-02) is operating aboard the International Space Station since May 2011, measuring cosmic rays in the GeV to TeV energy range. The isotopic composition of cosmic ray nuclei is strongly connected to their propagation in the Milky Way. Deuterons can be efficiently separated from the background of protons and helium nuclei by means of their mass, reconstructed by combining the velocity, charge and momentum, measured by different sub-detectors, namely the RICH, the Time of Flight and the tracker.

In this work, we will present our deuteron identification strategy, based on the mass reconstruction with the AMS-02 Ring Imaging CHerenkov (RICH). Our method aims at identifying with great precision the signal among the background of protons and heavier nuclei fragmenting inside the AMS-02 detector.

Primary authors: FERRONATO BUENO, Eduardo (University of Groningen); VECCHI, Manuela

Presenter: FERRONATO BUENO, Eduardo (University of Groningen)

Contribution ID: **28** Type: **oral**

A Study of Astrophysical Backgrounds of Antihelium Nuclei in Cosmic Rays

Thursday, March 28, 2019 5:00 PM (20 minutes)

Presence of larger antinuclei (i.e. antideuterons, antihelium) in the cosmic rays (CR) can be smoking gun signatures of indirect detection of Dark Matter (DM) annihilations. Recent reports of antihelium nuclei candidate events by AMS-02 experiment have generated interest in the community. However, lack of observations of antideuterons in CR so far have opened up questions about possible astrophysical backgrounds and their propagation in antinuclei measurements. In this study we explore the possibilities of producing antihelium nuclei from CR (mostly) protons with different energies and interstellar medium (ISM - mostly hydrogen) via the coalescence mechanism using the EPOS-LHC hadronic event generator and an afterburner. In comparison to simplified analytical methods, this way the correlations between the constituent nucleons are taken into account. This technique applied the coalescence condition on a event-by-event basis. Different methods of combining multiple nucleons to form larger antinuclei were considered. The analysis is highly computation intensive given the rare nature of antihelium production in $p+p$ interactions. Source terms for the galactic propagations of the antihelium were determined and compared with current literarure. Preliminry results of the propagation are also going to be presented.

Primary author: Dr DATTA, Amaresh (University of Hawaii at Manoa)

Co-authors: SHUKLA, Anirvan (University of Hawaii at Manoa); KANITZ, Carina (FAU Erlangen–Nürnberg); Prof. VON DOETINCHEM, Philip (University of Hawaii)

Presenter: Dr DATTA, Amaresh (University of Hawaii at Manoa)

Contribution ID: **29** Type: **oral**

EPOS Models and Anti-Deuterium Production

Thursday, March 28, 2019 3:00 PM (30 minutes)

To extract an exotic signal from the very precise AMS-02 data, it is very important to determine the astrophysical background. The latter depends on the accuracy of the various cross-sections needed for the anti-proton or anti-nuclei production. To fully cover the phase-space, hadronic interaction models are needed to extrapolate from what is measured in laboratories to what is needed to model astrophysical sources or cosmic-ray propagation. The different versions of the EPOS event generator have been developed to understand heavy ion collisions, which allows them to be used in astroparticle physics. One particularity of these models is, that they include the production of a high energy density core which hadronize following a statistical production of secondary particles, even in light system. As a consequence, the production of anti-baryons is modified compared to traditional string fragmentation, and it is possible to produce anti-nuclei directly without using a coalescence model. The results of the model will be studied in particular in view of the recent LHC data on collective hadronization in p-p and p-Pb collisions.

Primary author: PIEROG, Tanguy

Presenter: PIEROG, Tanguy

Contribution ID: **30** Type: **oral**

Antiproton Flux in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the ISS

Wednesday, March 27, 2019 10:15 AM (30 minutes)

The fluxes and flux ratios of charged elementary particles in cosmic rays are presented in the absolute rigidity range from 1 to 1000 GV. In the absolute rigidity range ~60 to ~500 GV, the antiproton and proton are found to have nearly identical rigidity dependence. Below 60 GV, the antiproton-to-proton, ratio reaches a maximum. Future perspectives for antiproton flux measurement will also be discussed.

Primary author: ZUCCON, Paolo (Trento University, Italy)

Presenter: ZUCCON, Paolo (Trento University, Italy)

Contribution ID: **31** Type: **oral**

AMS-100 –The next generation magnetic spectrometer in Space

The space based cosmic rays experiments PAMELA, AMS and FERMI have covered in the last decade the physics of cosmic rays up to the TeV scale with high precision. To extend this energy range significantly requires a new experimental concept. In this presentation a detector concept will be outlined for a large scale experiment at the Lagrange Point 2 (LP-2). It consists of a large high temperature super-conducting magnet, a combined silicon and scintillating fiber tracker, a time of flight system and an calorimeter. The design follows the cylindrical geometry of the pioneering BESS balloon experiment and allows for an acceptance of 100 m2 sr and an MDR of 100 TV. Most of the sky will be covered continuously. Using converted photons the angular resolution is improved significantly compared to FERMI in the TeV range. With the next generation of rockets expected to be available around the year 2025 in the US and China it will be possible to launch such an experiment with a typical weight of 45 tons to the LP-2. The detector concept and the physics program will be discussed.

Primary author: Prof. SCHAEL, Stefan (RWTH Aachen University)

Presenter: Prof. SCHAEL, Stefan (RWTH Aachen University)

Contribution ID: **32** Type: **not specified**

Deuteron, antiproton and antideuteron production cross-section studies for nucleus-nucleus collisions at the NA61/SHINE experiment.

Thursday, March 28, 2019 5:40 PM (20 minutes)

NA61/SHINE is a large-acceptance fixed-target experiment located at the CERN SPS, which studies final hadronic states in interactions of various particles and nuclei. It is unique in terms of providing data on a variety of collision systems at different collision energies. This allows for extensive deuteron, antiproton and antideuteron production cross-section studies. My talk will focus on heavier collision systems like p+C or pion+C. I will present a preliminary analysis of experimental data and discuss quality cuts and the particle identification method as well as present deuteron, antiproton, and antideuteron yields as a function of momentum.

Primary author: NASKRĘT, Michał

Presenter: NASKRĘT, Michał

Contribution ID: **33** Type: **oral**

The GAPS Detector: Design and Recent Developments

Thursday, March 28, 2019 9:15 AM (30 minutes)

The General AntiParticle Spectrometer (GAPS) is a balloon-borne cosmic-ray antimatter experiment. It will be sensitive to antideuterons with 0.05 < T < 0.25 GeV / nucleon and antiprotons with 0.07 < T < 0.25 GeV. Unlike a traditional cosmic ray detector, it has no requirement for strong magnetic fields but instead uses the exotic atom technique. The GAPS design is based on a lithium-drifted silicon (Si(Li)) tracker and plastic scintillator time of flight (TOF) system.

The TOF system includes an outer "umbrella"consisting of 132 counters covering an area of 38 m^2 and an inner "cube"with 64 counters and area of 15 m^2, in a near hermetic design. The counters will be mechanically secured to the gondola using an innovative carbon fiber structure. Each counter end will be read out using a silicon photomultiplier (SiPM) based analog front end designed to achieve ~500 ps resolution. The timing signals are sampled and digitized with a custom readout board that uses the DRS-4 ASIC. A local trigger monitors multiple programmable threshold levels for all 392 counter ends. A master trigger analyzes the local trigger hit patterns and initiates a TOF read out for an interesting event. A central computer analyzes the waveforms and estimates the primary's β, composition, and can be used to study decay product multiplicity.

The tracker system is comprised of ~1000 10 cm-diameter Si(Li) strip detectors, arranged in 10 planes. A custom fabrication technique was developed, in partnership with Shimadzu Corp., to satisfy the unique geometric, performance, and cost requirements of GAPS. To meet the formidable mission, requirements a custom ASIC has been developed to sample and digitize the 8-strips of each detector. The low noise design has a dynamic range of 10 keV to 100 MeV. For added efficiency and simplicity the tracker will be tightly integrated with balloon craft systems which inherit proven designs of past missions. To ensure the stability of the ~4 keV Si(Li) energy resolution at a relatively high operating temp of -40 C, the volume will be thermally regulated by a custom oscillating heat pipe system. This unique, low power design eliminates the need for traditional, heavy cryogenic systems. Tracker data analyzed by the flight computer provides essential information about the event vertex and annihilation products: as the exotic atom decays, antiprotons and antideuterons have characteristic and unique X-ray emission.

In this talk, I will review the history of the GAPS mission, and describe the instrument systems mentioned above in more detail.

Primary author: QUINN, Sean (UCLA)

Presenter: QUINN, Sean (UCLA)

Contribution ID: **34** Type: **oral**

Antihelium from dark matter

Thursday, March 28, 2019 11:05 AM (30 minutes)

I will review the status of predictions for antihelium production from dark matter annihilation or decay, highlighting the role of theory uncertainties and the constraints from antiproton measurements. I will also discuss potential dark matter candidates likely to produce significant amounts of cosmic antinuclei.

Primary author: PROFUMO, Stefano (UC Santa Cruz)

Presenter: PROFUMO, Stefano (UC Santa Cruz)

Contribution ID: **35** Type: **oral**

Study of (anti)deuteron production mechanism in proton-proton interactions

Thursday, March 28, 2019 5:20 PM (20 minutes)

The detection of cosmic-ray antideuterons is a potential breakthrough approach for the identification of dark matter. Antideuterons can also be produced in interactions of abundant primary cosmic-ray particles (mostly protons) with the interstellar medium (mostly hydrogen). However, production of light (anti)nuclei in proton-proton interactions is not very well understood. A better understanding of these mechanisms is needed, which motivates the effort to analyze large data sets from fixed-target experiments. This will help in reducing the uncertainties in antideuteron formation, which will boost cosmic-ray antideuteron searches and their interpretation.

The NA61/SPS Heavy Ion and Neutrino Experiment (NA61/SHINE) is a fixed-target experiment at the CERN SPS, which studies hadron production in hadron-nucleus and nucleus-nucleus collisions for various physics goals. This talk will review the analysis of large data sets of proton-proton interactions from NA61/SHINE. Progress made towards measurement of production cross-section of (anti)deuterons and the deuteron-to-proton ratio as a function of transverse momentum will be shown. The further tuning of current Monte Carlo event generators like EPOS-LHC based on this analysis will be discussed.

Primary author: SHUKLA, Anirvan (University of Hawaii at Manoa)

Co-authors: Prof. VON DOETINCHEM, Philip (University of Hawaii); DATTA, Maresh (UH Manoa)

Presenter: SHUKLA, Anirvan (University of Hawaii at Manoa)

Contribution ID: **36** Type: **oral**

Status of the GAPS simulation and analysis development

Thursday, March 28, 2019 9:45 AM (30 minutes)

The General Anti Particle Spectrometer (GAPS) is a balloon-borne cosmic-ray experiment scheduled for long duration balloon flights from McMurdo station in the Antarctic. Its primary science goal is the search for light antinuclei in cosmic rays at energies in the region below 0.3 GeV/n. This energy region is of great interest and still mostly uncharted. Searches for light antimatter nucleons with energies below ~0.3 GeV/n promise a potential break-through approach for the search of dark matter. GAPS will search with unprecedented sensitivity for antiprotons and especially antideuterons.

To reach the required sensitivity, the GAPS instrument incorporates a new approach for antimatter detection, utilizing a time of flight system together with a tracker with lithium-drifted silicon detectors in a novel design. The instrument is capable of measuring beta and dE/dx profiles of tracks together with exotic-atomic X-ray deexcitations emerging from antimatter captures in the tracker material. The observation of the X-ray cascade from exotic atoms is a golden channel for the identification of antideuterons.

In this talk, an overview will be given of the current status of the GAPS simulation and analysis framework. The focus will be set on simulation of light antinuclei interaction as well as identification techniques. We will present the current status of event reconstruction as well as discuss the GAPS antideuteron sensitivity.

Primary authors: STOESSL, Achim (UH Manoa); Prof. VON DOETINCHEM, Philip (University of Hawaii)

Presenter: STOESSL, Achim (UH Manoa)

Contribution ID: **37** Type: **oral**

Welcome

Wednesday, March 27, 2019 9:00 AM (15 minutes)

Presenter: Prof. ONG, Rene (UCLA)

Contribution ID: **38** Type: **oral**

Organization

Thursday, March 28, 2019 9:00 AM (15 minutes)

Presenter: Prof. ONG, Rene (UCLA)

Contribution ID: **39** Type: **oral**

Organization

Friday, March 29, 2019 9:00 AM (15 minutes)

Presenter: Prof. ONG, Rene (UCLA)

Contribution ID: **40** Type: **oral**

Goodbye

Friday, March 29, 2019 11:45 AM (15 minutes)

Presenter: Prof. VON DOETINCHEM, Philip (University of Hawaii)