

Antideuteron 2014

$\bar{d}14$ 1st cosmic ray
antideuteron workshop

Report of Contributions

Contribution ID: 1

Type: **not specified**

Antinuclei in space: a historical introduction

Thursday, June 5, 2014 9:10 AM (30 minutes)

As one of the crazy guys who started working in the field, I will present a short historical introduction to the production and propagation of antinuclei in space. I will summarize the essential ingredients – the factorization scheme, the coalescence momentum, the importance of kinematics in disentangling between secondary and dark matter antideuterons, spherical versus boosted coalescence – as well as the main steps and associated papers during the evolution of the field. I will conclude by presenting the current state of the art and associated open questions.

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

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

Contribution ID: 2

Type: **oral**

Antideuteron propagation in the Galaxy

Friday, June 6, 2014 10:00 AM (30 minutes)

I will review the effects of propagation of antideuterons in the Milky Way. The discussion will touch both the primary sources, such as the dark matter annihilating in the galactic halo, and the secondary ones, due to spallation of relativistic cosmic rays on the interstellar medium.

Primary author: Dr DONATO, Fiorenza (Torino University)

Presenter: Dr DONATO, Fiorenza (Torino University)

Contribution ID: 3

Type: **not specified**

Dark matter searches with cosmic antideuterons

Thursday, June 5, 2014 9:40 AM (30 minutes)

I will discuss the current understanding and open questions in the theoretical determination of the cosmic antideuteron dark matter signal.

Primary author: Prof. FORNENGO, Nicolao (University of Torino and INFN)

Presenter: Prof. FORNENGO, Nicolao (University of Torino and INFN)

Contribution ID: 4

Type: **not specified**

Status and challenges of the coalescence model

Friday, June 6, 2014 3:45 PM (30 minutes)

One key ingredient in the calculation of the antideuteron yield from both dark matter annihilations and cosmic ray spallations is the coalescence model, which is the phenomenological description of the formation of antideuterons from antiproton-antineutron pairs. In this talk, I will discuss the status and challenges of the coalescence model, as well as the resulting uncertainties in the prediction of antideuteron fluxes.

Primary author: Mr WILD, Sebastian (Technical University Munich)

Presenter: Mr WILD, Sebastian (Technical University Munich)

Contribution ID: 5

Type: **not specified**

Indirect dark matter detection using cosmic antideuterons - status and prospects

Thursday, June 5, 2014 10:10 AM (30 minutes)

The search for cosmic antideuterons has been proposed as a promising and clean method to indirectly detect dark matter, due to the very small background flux from spallations expected at the energies relevant to experiments. In this talk I will first present an updated calculation of the background flux, and then discuss the prospects to observe antideuterons from dark matter annihilations or decays in current and future experiments, taking into account the important correlation of the antideuteron flux with the well-measured antiproton-to-proton fraction.

Primary author: Mr WILD, Sebastian (Technical University Munich)

Presenter: Mr WILD, Sebastian (Technical University Munich)

Contribution ID: 6

Type: **not specified**

Antiprotons and Antideuterons from Gravitino Decay

Thursday, June 5, 2014 11:10 AM (30 minutes)

I will discuss antiprotons and antideuterons produced in the decays of gravitino dark matter in the Milky Way. The gravitino in models with bilinear (or trilinear) R-parity violation is a well-motivated candidate for decaying dark matter in supergravity theories. I will show that observations of cosmic-ray antiprotons allow to set stringent constraints on the gravitino lifetime. Moreover, I will present an updated calculation of the antideuteron flux expected from gravitino decays and briefly comment on the detection prospects in current and planned experiments.

Primary author: Dr GREFE, Michael (Universität Hamburg)

Presenter: Dr GREFE, Michael (Universität Hamburg)

Contribution ID: 7

Type: **not specified**

Prospects of antideuteron detection with AMS

Friday, June 6, 2014 11:00 AM (30 minutes)

AMS (Alpha Magnetic Spectrometer) is an experiment designed to perform a very precise measurement of the cosmic-ray spectrum at the top of the Earth's atmosphere, covering the energy range from hundreds of MeV to the TeV. The AMS-02 detector was installed aboard the International Space Station on 19 May 2011. The rate of event collection is approximately 500 Hz or $1.6 \cdot 10^{10}$ events per year. An unprecedented statistics ($\sim 5 \cdot 10^{10}$ events) has already been collected during the past three years and data acquisition is expected to continue for another decade.

Antideuterons have never been detected in cosmic rays. Dark matter annihilation is expected to produce an antideuteron flux in the energy region below 1 GeV which may be within the reach of AMS statistics. However, detecting an antideuteron signal requires a very effective rejection of background from a number of much more abundant particle species (protons, deuterons, electrons, positrons, antiprotons, ...) through a combination of reliable mass and charge measurements.

Particle identification with AMS-02 relies on a number of subdetectors aimed at providing independent measurements of particle velocity, rigidity and charge. The ongoing work to improve the quality of AMS-02 measurements to reach the level required for antideuteron detection will be presented. Implications for indirect dark matter detection will be discussed.

Primary authors: Prof. VON DOETINCHEM, Philip (University of Hawaii); Dr FAISCA RODRIGUES PEREIRA, Rui Miguel (University of Hawaii at Manoa)

Presenter: Dr FAISCA RODRIGUES PEREIRA, Rui Miguel (University of Hawaii at Manoa)

Contribution ID: 8

Type: **not specified**

Recent Developments in Geant4

Friday, June 6, 2014 2:00 PM (30 minutes)

The Geant4 simulation toolkit has advanced along many fronts in the past year with a major release implementing multi-threading and event level parallelism. In electromagnetic physics, improvements to the multiple scattering models were made, amongst other developments. The radioactive decay package was improved and extended. Developments in Geant4 hadronics include improved cascade models, improved low energy neutron models and extensions to high energy models which allow interactions of anti-deuterons and anti-alphas with matter. All of these items will be discussed, with emphasis on the anti-particle interactions.

Primary author: Dr WRIGHT, Dennis (SLAC)

Presenter: Dr WRIGHT, Dennis (SLAC)

Contribution ID: 9

Type: **not specified**

Dark matter searches with cosmic antihelium

Thursday, June 5, 2014 4:30 PM (30 minutes)

Galactic dark matter annihilations (or decay) can produce cosmic-ray anti-nuclei via the nuclear coalescence of the anti-protons and anti-neutrons originated directly from the annihilation process. Since anti-deuterons have been shown to offer a distinctive dark matter signal, with potentially good prospects for detection in large portions of the dark matter particle parameter space, we explore here the production of heavier anti-nuclei, specifically anti-helium as an additional channel of exploration.

Primary author: FORNENGO, Nicolao (University of Torino and INFN)

Presenter: FORNENGO, Nicolao (University of Torino and INFN)

Contribution ID: **10**

Type: **not specified**

Hadronization Dependence in Antideuteron Production

Friday, June 6, 2014 3:00 PM (30 minutes)

I will discuss the influence of hadronization on antideuteron formation.

Antideuteron production in the coalescence model depends on momentum differences between nucleons that are small compared to Λ_{QCD} , which makes the process highly sensitive to the hadronization model employed.

I will further discuss the prospects of reducing the uncertainty from hadronization by tuning Monte Carlo generators specifically for antideuteron production.

Primary author: DAL, Lars Andreas (University of Oslo)

Presenter: DAL, Lars Andreas (University of Oslo)

Contribution ID: 11

Type: **not specified**

Antihelium from Dark Matter

Thursday, June 5, 2014 5:00 PM (30 minutes)

Cosmic-ray anti-nuclei provide a promising discovery channel for the indirect detection of particle dark matter. Hadron showers produced by the pair-annihilation or decay of Galactic dark matter generate anti-nucleons which can in turn form light anti-nuclei. Previous studies have only focused on the spectrum and flux of low energy antideuterons which, although very rarely, are occasionally also produced by cosmic-ray spallation. Heavier elements ($A \geq 3$) have instead an entirely negligible astrophysical background for plausible detection scenarios, with a primary yield from dark matter which could be detectable by future experiments. In this talk, I will discuss our recent computation of antihelium production due to annihilating or decaying dark matter using an event-by-event Monte Carlo analysis. We will then employ semianalytic models for interstellar and heliospheric transport in order to obtain the local flux. Finally, we will discuss scaling relations which relate antihelium to antideuteron fluxes and briefly mention prospects for detection at current and future experiments, including GAPS and AMS-02.

Primary author: Mr CARLSON, Eric (University of California Santa Cruz)

Co-author: Mr WILD, Sebastian (Technical University Munich (TUM))

Presenter: Mr CARLSON, Eric (University of California Santa Cruz)

Contribution ID: 12

Type: **not specified**

The PAMELA experiment and antimatter in the Universe

Thursday, June 5, 2014 12:10 PM (30 minutes)

Antiparticles are a natural component of the cosmic radiation being produced in the interaction between cosmic rays and the interstellar matter. They have been shown to be extremely interesting for understanding the propagation mechanisms of cosmic rays. Furthermore, positrons and antiprotons may also be created by dark matter particle annihilations in the galactic halo. Positrons can also be created in the magnetospheres of near-by pulsars.

Cosmic-ray positrons and antiprotons were first observed in pioneering experiments in the sixties and seventies, respectively. The relatively small flux of cosmic-ray antiparticles combined with the presence of huge backgrounds of particles make these searches extremely challenging.

The PAMELA satellite-borne experiment has been measuring cosmic-ray antiparticle for nearly eight years. The combination of a permanent magnet silicon strip spectrometer and a silicon-tungsten imaging calorimeter allows precision studies of the antiparticle component to be conducted over a wide energy range with high statistics. In this talk we will review the PAMELA antiparticle results discussing the experimental uncertainties and challenges.

Primary author: Dr BOEZIO, Mirko (Istituto Nazionale di Fisica Nucleare - Sezione di Trieste)

Presenter: Dr BOEZIO, Mirko (Istituto Nazionale di Fisica Nucleare - Sezione di Trieste)

Contribution ID: 13

Type: **not specified**

Antideuteron Production Measurements from BaBar

Friday, June 6, 2014 12:00 PM (30 minutes)

As limits on their flux improves, cosmic ray antideuterons are expected to be a powerful low-background probe of dark matter annihilation to colored particles. Despite their promise in this field, the spectrum and rate of production of antideuterons from hadronization processes is still highly uncertain. We present measurements of the production rates of antideuterons in Upsilon (nS) ($n=(1,2,3)$) decays to hadrons and in continuum electron-positron annihilation to quarks performed using data collected by the BaBar detector running at the PEP-II asymmetric-energy electron-positron collider in the center-of-mass energy region near the Upsilon resonances. The results include the most precise measurement of the inclusive production rate in Upsilon(2S) decay and the first results from continuum annihilation and Upsilon(3S) decay.

Primary author: Dr HAMILTON, Brian (University of Maryland)

Presenter: Dr HAMILTON, Brian (University of Maryland)

Contribution ID: 14

Type: **not specified**

Antiproton identification with the AMS-02 detector

Thursday, June 5, 2014 3:00 PM (30 minutes)

The second generation of the Alpha Magnetic Spectrometer - AMS-02 - is a state-of-the-art detector that has been operating onboard the International Space Station (ISS) for the last 3 years; since then, more than 48 billion events have been detected. One of the goals of AMS-02 is to search for antimatter and dark matter. The AMS-02 detector is composed of several sub-detectors, which can be used for precise determination of particle species and its mass.

In this talk, we show a method for antiproton background separation in addition to separating particle species using the Tracker, Time-Of-Flight (TOF) and Ring Imaging CHerenkov Detector (RICH) subsystems in their optimal energy regimes.

Since antideuterons have yet to be detected in the current data, we also demonstrate how one can separate antiprotons from pions and kaons.

Primary authors: Dr HOFFMAN, Julia (National Central University, Taiwan); Dr HAINO, Sadakazu (Academia Sinica, Taiwan)

Presenter: Dr HOFFMAN, Julia (National Central University, Taiwan)

Contribution ID: 15

Type: **not specified**

Recent Results from the AMS-02 experiment

Thursday, June 5, 2014 11:40 AM (30 minutes)

The Alpha Magnetic Spectrometer (AMS-02) is a precision large-acceptance high energy particle detector which was successfully deployed in 2011 on the International Space Station (ISS) where it will operate for the next decades. To date, the detector has collected over 50-billion cosmic ray events. Among the physics objectives of AMS are a search for the understanding of Dark Matter, Antimatter, the origin of cosmic rays and the exploration of new physics phenomena. This report overviews operations and performance of the AMS-02 detector on the ISS as well as the results based on data collected during the first three years of operations in space.

Primary author: Dr BINDI, Veronica (UH)

Presenter: Dr BINDI, Veronica (UH)

Contribution ID: 16

Type: **not specified**

The GAPS Experiment for Indirect Dark Matter Detection

Thursday, June 5, 2014 2:30 PM (30 minutes)

There are many current searches for WIMP dark matter: direct, production, and indirect. The combination of all three offer a large amount of complementarity in probing parameter space. A particularly promising indirect search can be performed by the General Antiparticle Spectrometer (GAPS). A number of very exciting dark matter candidates are predicted to produce an excess of antideuterons in the cosmic rays arriving at Earth. GAPS has unprecedented sensitivity to cosmic ray antideuterons (and very good antiproton sensitivity) in the energy regime of interest (<200 GeV/n).

Primary author: Dr MOGNET, Isaac (UCLA)

Presenter: Dr MOGNET, Isaac (UCLA)

Contribution ID: 17

Type: **not specified**

Monte Carlo generators of high energy hadronic collisions: applications for secondary cosmic rays

Friday, June 6, 2014 2:30 PM (30 minutes)

I shall briefly review Monte Carlo models of hadronic and nuclear interactions, used in the high energy cosmic ray field. In particular, I'll illustrate the possibility to push some of those models into the low energy range, with potential applications for calculations of gamma-ray and antiproton fluxes. A special attention will be devoted to the calculation of the so-called nuclear enhancement factors. A relevance to calculations of antideuteron production will be also discussed.

Primary author: Dr OSTAPCHENKO, Sergey (Stanford University)

Presenter: Dr OSTAPCHENKO, Sergey (Stanford University)

Contribution ID: 18

Type: **not specified**

(Anti)Nuclei production at the LHC with ALICE

Friday, June 6, 2014 11:30 AM (30 minutes)

The unprecedented high collision energies at the Large Hadron Collider give rise to a significant production of light nuclei and anti-nuclei in proton-proton, proton-lead, and particularly in Pb-Pb collisions. With its excellent particle identification capabilities based on the specific energy loss (dE/dx) in the Time Projection Chamber and time-of-flight measurements, ALICE is very well suited for the detection of these rare stable particles. Transverse-momentum spectra and production yields of light composite objects such as (anti-)nuclei with particular emphasis on (anti-)deuteron will be presented. Furthermore, to understand their production mechanism, the results will be compared to the predictions from thermal and coalescence models.

Primary author: Dr BUFALINO, Stefania (INFN-Sezione di Torino)

Presenter: Dr BUFALINO, Stefania (INFN-Sezione di Torino)

Contribution ID: **19**

Type: **not specified**

Welcome

Thursday, June 5, 2014 9:00 AM (10 minutes)

Presenter: Prof. ONG, Rene (UCLA)

Contribution ID: 20

Type: **not specified**

Including anti-deuteron observables in global fits to new physics scenarios

Thursday, June 5, 2014 4:00 PM (30 minutes)

The propagation of cosmic rays (CRs) is still poorly understood, but it plays a key role in the physical processes of our Galaxy. By understanding CR propagation, we can determine which objects produce and accelerate them, and gain insights into the nature of dark matter. Anti-deuterons are a very promising and timely CR channel in which to look for indirect evidence of dark matter annihilation, because at low energies there is almost no astrophysical background, and experiments will reach the sensitivity required to probe dark matter models within 5 years. To fully exploit future data, we use improved anti-deuteron production as well as CR propagation models, and incorporate those models and their uncertainties into a global statistical analysis combining data from CRs and other collider, direct and indirect searches for dark matter. The result will be a simultaneous fit to CR propagation and dark matter models, providing the best understanding to date of the impacts of anti-deuteron searches on theories of dark matter.

Primary author: Dr PUTZE, Antje (LAPTh/LAPP)

Presenter: Dr PUTZE, Antje (LAPTh/LAPP)

Contribution ID: 21

Type: **not specified**

Search for Cosmic-Ray Antideuterons with the BESS-Polar Spectrometer

Thursday, June 5, 2014 2:00 PM (30 minutes)

The BESS collaboration carried out 11 scientific balloon flights including two long-duration flights over Antarctica during 16 years from 1993 to 2008. Taking advantage of the quick turnaround between balloon flights, the instrument was improved and adapted to our specific scientific objectives flight by flight. The evolution of BESS antiproton measurements is a great example. These started with 6 antiprotons identified in the cosmic radiation using the data from the first flight in 1993, and ended with more than 8000 antiprotons identified using the data from BESS-Polar II flight in 2007/2008. These data enabled us to provide the definitive answer for the possibility of the existence of low energy primary antiprotons in the cosmic radiation. The data show no evidence of primary antiprotons from evaporation of primordial black holes. No antihelium candidates were found in the all flight data and set the most stringent upper limit reported of 6.9×10^{-8} for the abundance ratio of antihelium/helium in the rigidity range of 1-14 GV. The most sensitive antideuteron search reported used the data obtained by BESS97, BESS98, BESS99, and BESS00, which include the previous solar minimum period in 1997. By comparison, the BESS- Polar II flight accumulated cosmic-ray data in near solar minimum conditions with more than ten times the statistics of BESS97. We will report the status of a new search for antideuterons using BESS- Polar II data.

Primary author: Dr SASAKI, Makoto (NASA/GSFC/CRESST/UMCP)

Presenter: Dr SASAKI, Makoto (NASA/GSFC/CRESST/UMCP)

Contribution ID: 22

Type: **not specified**

Secondaries from supernova remnants and new AMS-02 data

Friday, June 6, 2014 9:30 AM (30 minutes)

Recently, the AMS-02 collaboration has presented data on cosmic ray protons, Helium, electrons and positrons as well as the boron-to-carbon ratio. We present the first consistent modelling of these data, paying particular attention to the contribution due to production and acceleration of secondary electrons and positrons in nearby supernova remnants. This process results in an additional, harder component that becomes dominant at high energies and can explain the rise in the positron fraction observed earlier by PAMELA. We find a concomitant rise in the boron-to-carbon ratio at somewhat higher energies, still in agreement with the latest AMS-02 data. We comment on how data on the antiproton-to-proton ratio (that will be available by the time of this conference) can be used to test this model and distinguish it from other astrophysical explanations of the rise in the positron ratio.

Primary author: MERTSCH, Philipp (KIPAC, Stanford University)

Co-author: Prof. SARKAR, Subir (University of Oxford)

Presenter: MERTSCH, Philipp (KIPAC, Stanford University)

Contribution ID: 23

Type: **not specified**

Collider experiments for studying antideuteron physics

This talk will give a short overview of experiments other than ALICE and BaBar with capabilities to study antideuteron physics.

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

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

Contribution ID: 24

Type: **not specified**

Discussion: path into the future for antideuterons

Friday, June 6, 2014 4:45 PM (45 minutes)

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

Contribution ID: 25

Type: **not specified**

Dark matter indirect detection signals and constraints

Friday, June 6, 2014 4:15 PM (30 minutes)

I will give an overview of potential signals from indirect dark matter detection and commensurate constraints, including the cosmic ray positron fraction and gamma rays from the Galactic Center. Both are very statistically significant signals that also have astrophysical interpretations. I will tie in some implications for antideuteron cosmic ray searches.

Primary author: Prof. ABAZAJIAN, Kevork (University of California, Irvine)

Presenter: Prof. ABAZAJIAN, Kevork (University of California, Irvine)

Contribution ID: 26

Type: **not specified**

Can Primordial Antideuterons be Detected in the Cosmic Radiation?

Friday, June 6, 2014 9:00 AM (30 minutes)

I present a simple analytic model for the diffusion of cosmic rays through intergalactic space. Estimates for the intergalactic magnetic field provide severe constraints on the mean free path for cosmic ray diffusion. For reasonable models and energies below 10^6 GeV, a completely negligible number of particles can enter our Galaxy from distances greater than ~ 100 Mpc. Particle destruction in galaxies along the diffusion path results in an exponential suppression of any possible flux of extragalactic cosmic rays. Finally, the diffuse gamma ray flux can be used to conclude that any hypothetical domains of anti-matter must be at distances exceeding the horizon scale. Even in the extreme case of a baryon symmetric universe, cosmic rays are shown to be an ineffective tool to search for primordial antideuterons.

Primary author: Prof. TARLÉ, Gregory (University of Michigan)

Presenter: Prof. TARLÉ, Gregory (University of Michigan)