

TASI Lectures on the Particle Physics and Astrophysics of Dark Matter

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These lecture notes on the particle physics and astrophysics of dark matter (DM) were delivered at TASI 2022 “Ten Years After the Higgs Discovery: Particle Physics Now and Future.” The focus of these lecture notes, aimed at the level of advanced graduate students and beginning postdocs, is on indirect (*i.e.*, astrophysical and cosmological) probes of particle DM models. While DM models and indirect detection are broadly discussed, the examples of weakly interacting massive particles (WIMPs) and axions are worked out in detail. The topics covered include: the role of DM in the cosmology and astrophysics of structure formation, including DM density profiles in galaxies, general constraints on particle DM models, the theory of minimal DM, with the higgsino as a relevant and illustrative example, indirect detection with gamma-rays, including with the upcoming Cherenkov Telescope Array, axions as a solution to the strong- CP problem and a DM candidate, including discussions of possible ultraviolet completions and of axion string cosmology, and astrophysical probes of axions such as with isocurvature perturbations, N_{eff} , black hole superradiance, radio telescopes, spectral modulations, stellar polarization, and stellar cooling, amongst other topics. Example Jupyter notebooks are provided that walk the reader through relevant analyses, including an example statistical analysis of a DM annihilation search towards the Segue I dwarf galaxy with gamma-ray data from the *Fermi* Large Area Telescope that is relevant for DM explanations of the *Fermi* Galactic Center Excess. We also provide an introduction to frequentist statistics for particle and astro-particle physics. These lecture notes are meant to be pedagogical, with the focus on explaining the underlying physical principles and analysis techniques that are set to play crucial roles in the search for particle DM in the coming decade.

*TASI 2022 – “Ten Years After the Higgs Discovery: Particle Physics Now and Future,”
June 6 - July 1 2022
Boulder, CO USA*

Dark Matter Notes Lecture Tutorial

**Richard Raucci, Elizabeth Crane, Jerry
Yang**



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Astrophysics at Very High Energies Felix Aharonian, Lars Bergström, Charles Dermer, 2013-04-04 With the success of Cherenkov Astronomy and more recently with the launch of NASA's Fermi mission very high energy astrophysics has undergone a revolution in the last years This book provides three comprehensive and up to date reviews of the recent advances in gamma ray astrophysics and of multi messenger astronomy Felix Aharonian and Charles Dermer address our current knowledge on the sources of GeV and TeV photons gleaned from the precise measurements made by the new instrumentation Lars Bergström presents the challenges and prospects of astro particle physics with a particular emphasis on the detection of dark matter candidates The topics covered by the 40th Saas Fee Course present the capabilities of current

instrumentation and the physics at play in sources of very high energy radiation to students and researchers alike This book will encourage and prepare readers for using space and ground based gamma ray observatories as well as neutrino and other multi messenger detectors

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Table of Contents Dark Matter Notes Lecture Tutorial

1. Understanding the eBook Dark Matter Notes Lecture Tutorial
 - The Rise of Digital Reading Dark Matter Notes Lecture Tutorial
 - Advantages of eBooks Over Traditional Books
2. Identifying Dark Matter Notes Lecture Tutorial
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Dark Matter Notes Lecture Tutorial
 - User-Friendly Interface
4. Exploring eBook Recommendations from Dark Matter Notes Lecture Tutorial
 - Personalized Recommendations
 - Dark Matter Notes Lecture Tutorial User Reviews and Ratings
 - Dark Matter Notes Lecture Tutorial and Bestseller Lists
5. Accessing Dark Matter Notes Lecture Tutorial Free and Paid eBooks
 - Dark Matter Notes Lecture Tutorial Public Domain eBooks
 - Dark Matter Notes Lecture Tutorial eBook Subscription Services
 - Dark Matter Notes Lecture Tutorial Budget-Friendly Options
6. Navigating Dark Matter Notes Lecture Tutorial eBook Formats
 - ePub, PDF, MOBI, and More
 - Dark Matter Notes Lecture Tutorial Compatibility with Devices
 - Dark Matter Notes Lecture Tutorial Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Dark Matter Notes Lecture Tutorial
 - Highlighting and Note-Taking Dark Matter Notes Lecture Tutorial
 - Interactive Elements Dark Matter Notes Lecture Tutorial
8. Staying Engaged with Dark Matter Notes Lecture Tutorial

- Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Dark Matter Notes Lecture Tutorial
9. Balancing eBooks and Physical Books Dark Matter Notes Lecture Tutorial
- Benefits of a Digital Library
 - Creating a Diverse Reading Collection Dark Matter Notes Lecture Tutorial
10. Overcoming Reading Challenges
- Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Dark Matter Notes Lecture Tutorial
- Setting Reading Goals Dark Matter Notes Lecture Tutorial
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Dark Matter Notes Lecture Tutorial
- Fact-Checking eBook Content of Dark Matter Notes Lecture Tutorial
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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