KRITTIKA SUMMER PROJECTS 2023

Pictures/background.pd

Exploring the Radio Sky

Darsh Ambade

KRITTIKA SUMMER PROJECTS 2023

Exploring the Radio Sky

Darsh Ambade[1]

[1]Indian Institute of Science Education and Research, Mohali

PUBLISHED BY KRITTIKA: THE ASTRONOMY CLUB OF IIT BOMBAY
GITHUB.COM/KRITTIKAIITB
Project Code Repository: KSP-Gravitational-Waves
First Release, September 2023

Abstract

Radio astronomy has revolutionized our understanding of the Universe by probing celestial objects and phenomena by observing radio waves. This project report focuses on acquiring and analyzing radio astronomy data using prominent telescopes such as the Very Large Array (VLA) and the Giant Metrewave Radio Telescope (GMRT). The project begins with

an introduction to radio astronomy, providing a comprehensive overview of the principles and techniques involved. It covers the basics of radio wave propagation, instrumental components, and observational methods employed in the field. Additionally, the report delves into the significance of the 21cm line, a spectral line emitted by neutral hydrogen atoms, which is crucial in studying the distribution and evolution of cosmic structures.

Pictures//mainimage.pdf

Contents

Part One

Pictures//chapter_head_2.pdf

1. Introduction to the Radio Sky

1.1 Equatorial Coordinate System

The equatorial system is a celestial coordinate system commonly used in astronomy for precisely locating celestial objects on the celestial sphere. It provides a consistent reference frame that remains fixed with respect to the stars, allowing astronomers to accurately determine the positions of objects regardless of Earth's rotation. The celestial sphere is imagined as an extension of Earth's equatorial plane into space in the equatorial system. It is divided into two primary components: the celestial equator and the celestial poles. The celestial equator is an imaginary circle around the celestial sphere directly above Earth's equator. It divides the celestial sphere into two equal halves, the northern and southern celestial hemispheres.


Pictures/radec.pdf

Pictures//chapter_head_2.pdf

2. Working of a Radio Telescope

2.1 Theorems

This is an example of theorems.

2.1.1 Several equations

This is a theorem consisting of several equations.

Theorem 2.1.1 — Name of the theorem. In $E = \mathbb{R}^n$ all norms are equivalent. It has the properties:

$$\big|\,||\mathbf{x}|| - ||\mathbf{y}||\,\big| \leq ||\mathbf{x} - \mathbf{y}|| \tag{2.1}$$

$$||\sum_{i=1}^{n} \mathbf{x}_i|| \leq \sum_{i=1}^{n} ||\mathbf{x}_i|| \quad \text{where } n \text{ is a finite integer} \tag{2.2}$$

2.1.2 Single Line

This is a theorem consisting of just one line.

Theorem 2.1.2 A set $\mathscr{D}(G)$ in dense in $L^2(G), |\cdot|_0$.

2.2 Definitions

This is an example of a definition. A definition could be mathematical or it could define a concept.

Definition 2.2.1 — Definition name. Given a vector space E, a norm on E is an

application, denoted $||\cdot||$, E in $\mathbb{R}^+ = [0, +\infty[$ such that:

$$||\mathbf{x}|| = 0 \;\Rightarrow\; \mathbf{x} = \mathbf{0} \tag{2.3}$$
$$||\lambda \mathbf{x}|| = |\lambda| \cdot ||\mathbf{x}|| \tag{2.4}$$
$$||\mathbf{x} + \mathbf{y}|| \leq ||\mathbf{x}|| + ||\mathbf{y}|| \tag{2.5}$$

2.3 Notations

Notation 2.1. *Given an open subset G of $\mathbb{R}^n$, the set of functions φ are:*
1. *Bounded support G;*
2. *Infinitely differentiable;*

a vector space is denoted by $\mathscr{D}(G)$.

2.4 Remarks

This is an example of a remark.

R The concepts presented here are now in conventional employment in mathematics. Vector spaces are taken over the field $\mathbb{K} = \mathbb{R}$, however, established properties are easily extended to $\mathbb{K} = \mathbb{C}$.

2.5 Corollaries

This is an example of a corollary.

Corollary 2.5.1 — Corollary name. The concepts presented here are now in conventional employment in mathematics. Vector spaces are taken over the field $\mathbb{K} = \mathbb{R}$, however, established properties are easily extended to $\mathbb{K} = \mathbb{C}$.

2.6 Propositions

This is an example of propositions.

2.6.1 Several equations

Proposition 2.6.1 **— Proposition name.** It has the properties:

$$\big|\,||\mathbf{x}|| - ||\mathbf{y}||\,\big| \leq ||\mathbf{x} - \mathbf{y}|| \tag{2.6}$$
$$||\sum_{i=1}^{n} \mathbf{x}_i|| \leq \sum_{i=1}^{n} ||\mathbf{x}_i|| \quad \text{where } n \text{ is a finite integer} \tag{2.7}$$

2.6.2 Single Line

Proposition 2.6.2 Let $f, g \in L^2(G)$; if $\forall \varphi \in \mathscr{D}(G)$, $(f, \varphi)_0 = (g, \varphi)_0$ then $f = g$.

2.7 Examples

This is an example of examples.

2.7.1 Equation and Text

▪ **Example 2.1** Let $G = \{x \in \mathbb{R}^2 : |x| < 3\}$ and denoted by: $x^0 = (1,1)$; consider the function:

$$f(x) = \begin{cases} e^{|x|} & \text{si } |x - x^0| \leq 1/2 \\ 0 & \text{si } |x - x^0| > 1/2 \end{cases} \tag{2.8}$$

The function f has bounded support, we can take $A = \{x \in \mathbb{R}^2 : |x - x^0| \leq 1/2 + \varepsilon\}$ for all $\varepsilon \in]0;5/2 - \sqrt{2}[$. ▪

2.7.2 Paragraph of Text

▪ **Example 2.2 — Example name.** Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris. ▪

2.8 Exercises

This is an example of an exercise.

Exercise 2.1 This is a good place to ask a question to test learning progress or further cement ideas into students' minds. ▪

2.9 Problems

Problem 2.1 What is the average airspeed velocity of an unladen swallow?

2.10 Vocabulary

Define a word to improve a students' vocabulary.
Vocabulary 2.1 — Word. Definition of word.

Pictures//chapter_head_1.pdf

3. Presenting Information

3.1 Table

Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 3.1: Table caption

3.2 Figure

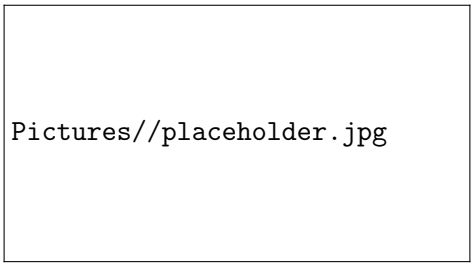

Figure 3.1: Figure caption

Pictures//chapter_head_1.pdf

Bibliography

Books

Articles

Pictures//chapter_head_1.pdf

Index