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JPL

Basics of Radio Astronomy

for the

Goldstone-Apple Valley

Radio Telescope

April 1998

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Prepared by

Diane Fisher Miller

Advanced Mission Operations Section

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Document Log

Basics of Radio Astronomy Learner's Workbook

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D-13835, Preliminary	3/3/97	Preliminary "Beta" release of document.
D-13835, Final	4/17/98	Final release of document. Adds discussions of superposition, interference, and diffraction in Chapter 4.

Preface

In a collaborative effort, the Science and Technology Center (in Apple Valley, California), the Apple Valley Unified School District, the Jet Propulsion Laboratory, and NASA have converted a 34-meter antenna at NASA's Deep Space Network's Goldstone Complex into a unique interactive research and teaching instrument available to classrooms throughout the United States, via the Internet. The Science and Technology Center is a branch of the Lewis Center for Educational Research.

The Goldstone-Apple Valley Radio Telescope (GAVRT) is located in a remote area of the Mojave Desert, 40 miles north of Barstow, California. The antenna, identified as DSS-12, is a 34-meter diameter dish, 11 times the diameter of a ten-foot microwave dish used for satellite television reception. DSS-12 has been used by NASA to communicate with robotic space probes for more than thirty years. In 1994, when NASA decided to decommission DSS-12 from its operational network, a group of professional scientists, educators, engineers, and several community volunteers envisioned a use for this antenna and began work on what has become the GAVRT Project.

The GAVRT Project is jointly managed by the Science and Technology Center and the DSN Science Office, Telecommunications and Mission Operations Directorate, at the Jet Propulsion Laboratory.

This workbook was developed as part of the training of teachers and volunteers who will be operating the telescope. The students plan observations and operate the telescope from the Apple Valley location using Sun workstations. In addition, students and teachers in potentially 10,000 classrooms across the country will be able to register with the center’s Web site and operate the telescope from their own classrooms.

Contents

Introduction

This module is the first in a sequence to prepare volunteers and teachers at the Science and Technology Center to operate the Goldstone-Apple Valley Radio Telescope (GAVRT). It covers the basic science concepts that will not only be used in operating the telescope, but that will make the experience meaningful and provide a foundation for interpreting results.

Acknowledgements

Many people contributed to this workbook. The first problem we faced was to decide which of the overwhelming number of astronomy topics we should cover and at what depth in order to prepare GAVRT operators for the radio astronomy projects they would likely be performing. George Stephan generated this initial list of topics, giving us a concrete foundation on which to begin to build. Thanks to the subject matter experts in radio astronomy, general astronomy, and physics who patiently reviewed the first several drafts and took time to explain some complex subjects in plain English for use in this workbook. These kind reviewers are Dr. M.J. Mahoney, Roger Linfield, David Doody, Robert Troy, and Dr. Kevin Miller (who also loaned the project several most valuable books from his personal library). Special credit goes to Dr. Steve Levin, who took responsibility for making sure the topics covered were the right ones and that no known inaccuracies or ambiguities remained. Other reviewers who contributed suggestions for clarity and completeness were Ben Toyoshima, Steve Licata, Kevin Williams, and George Stephan.

Assumptions and Disclaimers

This training module assumes you have an understanding of high-school-level chemistry, physics, and algebra. It also assumes you have familiarity with or access to other materials on general astronomy concepts, since the focus here is on those aspects of astronomy that relate most specifically to radio astronomy.

This workbook does not purport to cover its selected topics in depth, but simply to introduce them and provide some context within the overall disciplines of astronomy in general and radio astronomy in particular. It does not cover radio telescope technology, nor details of radio astronomy data analysis.

Learning Strategy

As a participant, you study this workbook by yourself. It includes both learning materials and evaluation tools. The chapters are designed to be studied in the order presented, since some concepts developed in later chapters depend on concepts introduced in earlier ones. It doesn't matter how long it takes you to complete it. What is important is that you accomplish all the learning objectives.

The frequent “Recap” (for recapitulation) sections at the end of each short module will help you reinforce key points and evaluate your progress. They require you to fill in blanks. Please do so either mentally or jot your answers on paper. Answers from the text are shown at the bottom of each Recap. In addition, “For Further Study” boxes appear throughout this workbook suggesting references that expand on many of the topics introduced. See “References and Further Reading” on Page 85 for complete citations of these sources.

After you complete the workbook, you will be asked to complete a self-administered quiz (fill in the blanks) covering all the objectives of the learning module and then send it to the GAVRT Training Engineer. It is okay to refer to the workbook in completing the final quiz. A score of at least 90% is expected to indicate readiness for the next module in the GAVRT operations readiness training sequence.

Help with Abbreviations and Units of Measure

This workbook uses standard abbreviations for units of measure. Units of measure are listed below. Refer to the Glossary in Appendix A for further help. As is the case when you are studying any subject, you should also have a good English dictionary at hand.

k	(with a unit of measure) kilo (10^3, or thousand)
M	(with a unit of measure) Mega (10^6, or million)
G	(with a unit of measure) Giga (10^9, or billion; in countries using the metric system outside the USA, a billion is 10^{12}. Giga, however, is always 10^9.)
T	(with a unit of measure) Tera (10^{12}, or a million million)
P	(with a unit of measure) Peta (10^{15})
E	(with a unit of measure) Exa (10^{18})
Hz	Hertz
K	Kelvin
m	meter (USA spelling; elsewhere, metre)
nm	nanometer (10^{-9} meter)