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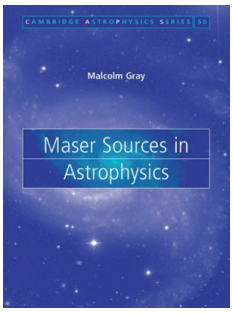

M. Gray
Maser Sources in Astrophysics

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Masers and lasers in the space are a well established reality. Masers were discovered in 1965 by professor Weaver and laser emission was observed in the atmosphere of Mars and Venus since 1976 by Townes and his students. A few books were written on the subject and a number of review papers have appeared. This new book by Malcolm Gray is a very welcome updated and complete discussion of the subject. After an introduction on masers and lasers in general, explaining the basic principles and giving the basis for the discussions to follow, the book discusses astrophysical masers considering all the different sides of the problems. The author chooses to consider all systems as masers (including also the CO_2 emission from the planetary atmospheres of Mars and Venus).

A first chapter (the second of the book) is dedicated to the history of the discovery considering also the various maser transitions from space. The rest of the book is dedicated to explaining in detail the generation of the radiation, its properties and its uses in astrophysics.

Chapter 3 is dedicated to a simplified discussion of the basic theory dividing it into two problems. One is the transfer of radiation through the medium containing the active molecules, and the other is the molecular physics required to calculate the inversion. The two problems are however interconnected.

Chapter 4 treats how maser radiation is observed, discussing the various kinds of radio-telescopes that are used, from radio to millimetre to sub-millimetre waves. Single dish and interferometric techniques are considered.

Not all the molecules discovered in space have been found to generate astrophysical masers. About 10% of them are able to generate maser radiation and an in-depth discussion of these molecules is made in chapter 5 considering each different molecule by itself.

Where are masers formed? Masers have been detected in a wide variety of astrophysical environments with a huge extension in the range of scales: the smallest scale are planetary atmospheres and comets. The largest masers form in molecular tori around the nuclei of certain galaxies and may be up to 1 kpc ($\sim 3{\cdot}10^{19}$ m) in size. Also the power of their emission varies on a large scale and one may distinguish masers, kilomasers and megamasers. Galactic star-forming regions are the most common place were astrophysical masers form. They are also associated with stars in the final stages of their lives, when they typically posses unstable atmospheres, undergoing rapid mass loss. Planetary nebulae and proto-planetary nebulae, supernova remnants, comets, hot stars and planetary atmosphere all form environments in which masers and megamasers may develop and are treated in chapter 6 which considers the astrophysical environments of masers.

At this point a more advanced theory using quantum theory and discussing in-depth polarization properties forms the object of chapter 7.

Except in very simple cases, it is not possible to solve the coupled molecular physics and radiation transfer problems of masers, or their pumping radiation analytically and it is necessary to resort to numerical solutions. Chapter 8 discusses some of the numerical methods that can be used.

The book ends with two chapters on the use of maser's emission as a diagnostic tool (chapter 9) and on the future prospects (chapter 10).

Some masers are particularly useful for measuring magnetic fields because they have a large Zeeman effect of hyperfine structure. Other masers and megamasers allow to measure the masses of the objects around which they are orbiting. Masers can be used to measure distances and help to measure the Hubble constant or probe the turbulence of the region in which they sit. All these applications are discussed in chapter 9.

A number of radioastronomy projects to study astrophysical masers and their environments such as EVLA, the Expanded Very Large Array, or e-MERLIN the Multi-Element Radio-Linked Interferometer Network are developing. These projects and a few other arrays (ALMA, SKA,VERA) are described in chapter 10.

Twelve appendices help the reader to understand some basic subjects such as Boltzmann's formula, vector identities, Dirac delta-function, etc.

An extended list of references is provided and a subject index is given.

The text is completed by a number of figures, graphics, and tables and the typographical presentation is good. The binding could perhaps be made more accurately as in my copy a few pages detached after a few days.

The book is clearly intended to specialists and as such it fulfils completely its scope. The subject is treated exhaustively and the references are sufficient to deepen any aspect of the discussion.

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