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Fiber Laser Tree Models

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GENERAL INTRODUCTION

Over the past few years, industries have had to come up with innovative technological solutions and materials tailored to environmental and economic requirements. Among these materials is a laser, which stands for "light amplification by stimulated emission of radiation," is a device that produces a coherent, focused beam of light through a process of stimulated emission. The basic principle behind lasers involves the interaction of atoms or molecules within an active medium. An active medium, which can be a solid, liquid or gas, contains atoms or molecules in an excited state. Among the types of lasers, there are fiber lasers operate based on the principle of stimulated emission, where light amplification occurs through the stimulated emission of photons. The gain medium in fiber lasers is an optical fiber doped with rare-earth elements such as erbium, ytterbium, or neodymium. When pumped with an external light source, these dopants absorb energy and become excited. Subsequently, the excited dopants emit photons that are confined within the fiber by total internal reflection, leading to the amplification of light. This process creates a population inversion, where more atoms are in the excited state than in the ground state, resulting in a powerful laser output.

Fiber lasers consist of several key components that work together to generate and amplify laser light. The core component is the active fiber, which acts as the gain medium and is doped with rare-earth elements. A pump source, typically laser diodes or fiber-coupled laser diodes, excites the dopants in the active fiber. The optical cavity, formed by two mirrors (one highly reflective and one partially reflective), provides the feedback loop necessary for light amplification. Wavelength selective elements, such as fiber Bragg gratings, may be incorporated to achieve spectral filtering. These components, combined with the inherent advantages of fiber lasers, contribute to their high efficiency, excellent beam quality, compact size, and reliability.

Fiber lasers have several advantages over traditional lasers, including higher efficiency, better beam quality, and greater flexibility in terms of design and operation. They are also more compact and lightweight, making them ideal for use in industrial and scientific applications including cutting, welding, marking, and engraving of various materials such as metals, plastics, and ceramics. They are also used in medical and scientific research, telecommunications, and defense systems [1-2].

The main objective of this research is to understand the function mechanism of fiber lasers and use simulations to explain the phenomenon of fiber lasers.

This thesis makes the following contributions: