

A1.1 The quantum mechanics of atoms and molecules

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A1.1.1 INTRODUCTION

At the turn of the 19th century, it was generally believed that the great distance between earth and the stars would forever limit what could be learned about the universe. Apart from their approximate size and distance from earth, there seemed to be no hope of determining intensive properties of stars, such as temperature and composition. While this pessimistic attitude may seem quaint from a modern perspective, it should be remembered that all knowledge gained in these areas has been obtained by exploiting a scientific technique that did not exist 200 years ago—spectroscopy.

In 1859, Kirchoff made a breakthrough discovery about the nearest star—our sun. It had been known for some time that a number of narrow dark lines are found when sunlight is bent through a prism. These absences had been studied systematically by Fraunhofer, who also noted that dark lines can be found in the spectrum of other stars; furthermore, many of these absences are found at the same wavelengths as those in the solar spectrum. By burning substances in the laboratory, Kirchoff was able to show that some of the features are due to the presence of sodium atoms in the solar atmosphere. For the first time, it had been demonstrated that an element found on our planet is not unique, but exists elsewhere in the universe. Perhaps most important, the field of modern spectroscopy was born.

Armed with the empirical knowledge that each element in the periodic table has a characteristic spectrum, and that heating materials to a sufficiently high temperature disrupts all interatomic interactions, Bunsen and Kirchoff invented the spectroscope, an instrument that atomizes substances in a flame and then records their emission spectrum. Using this instrument, the elemental composition of several compounds and minerals were deduced by measuring the wavelength of radiation that they emit. In addition, this new science led to the discovery of elements, notably caesium and rubidium.