Beyond Pluto
Exploring the outer limits of the solar system

In the last ten years, the known solar system has more than doubled in size. For the first time in almost two centuries an entirely new population of planetary objects has been found. This 'Kuiper Belt' of minor planets beyond Neptune has revolutionised our understanding of how the solar system was formed and has finally explained the origin of the enigmatic outer planet Pluto. This is the fascinating story of how theoretical physicists decided that there must be a population of unknown bodies beyond Neptune and how a small band of astronomers set out to find them. What they discovered was a family of ancient planetesimals whose orbits and physical properties were far more complicated than anyone expected. We follow the story of this discovery, and see how astronomers, theoretical physicists and one incredibly dedicated amateur observer have come together to explore the frozen boundary of the solar system.

JOHN DAVIES is an astronomer at the Astronomy Technical Centre in Edinburgh. His research focuses on small solar system objects. In 1983 he discovered six comets with the Infrared Astronomy Satellite (IRAS) and since then he has studied numerous comets and asteroids with ground- and space-based telescopes. Dr Davies has written over 70 scientific papers, four astronomy books and numerous articles in popular science magazines such as *New Scientist*, *Astronomy* and *Sky & Telescope*. Minor Planet 9064 is named Johndavies in recognition of his contributions to solar system research.

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To all my friends in Hawaii, especially those who made UKIRT the greatest infrared telescope in the world.

Contents

Preface

This is a story about a discovery and some of the developments which followed it. It is not a textbook. Although I hope it contains most of the relevant technical details I set out to show a little of how astronomy is actually done. Some of the characters spend their time looking through telescopes on the darkest of dark nights, others work in offices and laboratories far removed, both physically and psychologically, from mountaintop observatories. From time to time this diverse group of people come together, in small groups or *en masse*, to exchange ideas and dispute data. They do this in order to understand the origin and evolution of the solar system in which we live and work. A few names crop up frequently, for the community of solar system astronomers is a small one and our paths often meander across each other in unpredictable ways.

In the last few years a new, and dynamic, outer solar system has replaced the sterile border known to our predecessors. I still find it hard to believe how much our view of the solar system has changed in the last decade and even harder to credit that I have been a part of this adventure. It has been an exciting time for all of us, and some of my childhood dreams have come true in a way that I could never have imagined. I hope that some of this mystery and excitement comes through in these pages.

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Finally, my wife Maggie for reading and correcting the manuscript, even though it's not really her subject.

Prologue

In July 1943 the *Journal of the British Astronomical Association* published a short article entitled 'The Evolution of our Planetary System'. The paper had been submitted by a retired Irish soldier and part-time amateur theoretical astronomer, Lt-Col. Kenneth Edgeworth. Despite being greatly reduced in length due to wartime shortages of paper, the article contained a prophetic paragraph on the structure of the solar system. While discussing comets, Lt-Col. Edgeworth remarked, 'It may be inferred that the outer region of the solar system, beyond the orbits of the planets, is occupied by a very large number of comparatively small bodies.' Kenneth Edgeworth did not live to see his prediction confirmed, but almost 50 years later just such an object was discovered. This new body, initially called simply 1992 QB_1, was the harbinger of a breakthrough in our understanding of the solar system. Within a few years hundreds of similar objects would be found in what, by an ironic twist, soon became known as the Kuiper, rather than Edgeworth, Belt.