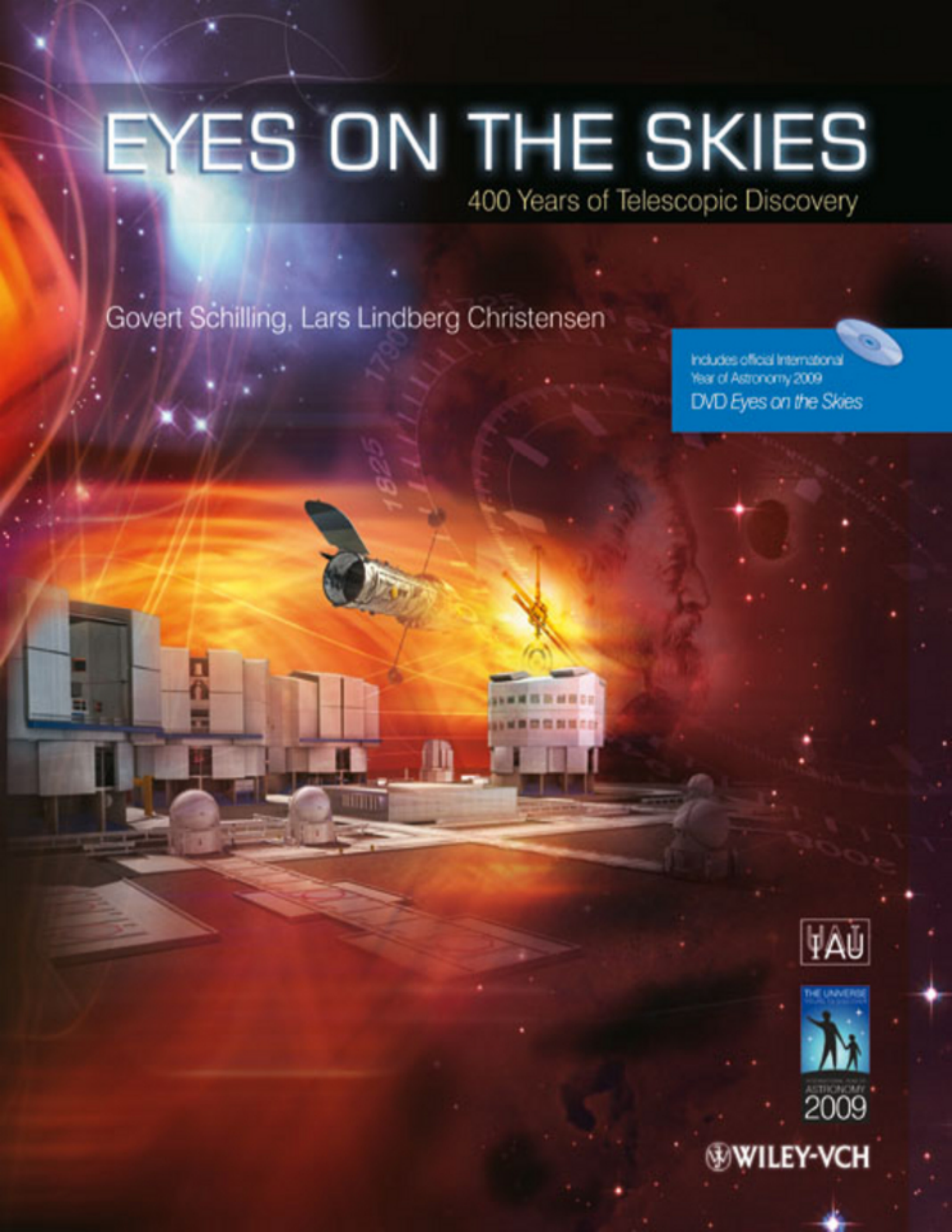



# EYES ON THE SKIES

400 Years of Telescopic Discovery

Govert Schilling, Lars Lindberg Christensen

Includes official International  
Year of Astronomy 2009  
DVD *Eyes on the Skies*



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*“The true origin of the telescope remains shrouded in mystery”*

*“It was time to train the telescope on the heavens”*

*“A landscape of craters, mountains, and valleys. A world like our own.”*

*“Not everything revolves around the Earth, as the Greeks had always believed”*

*“There was a whole Universe out there to discover”*

*“Herschel must surely have felt like a child let loose in a sweetshop”*

*“The largest of Herschel’s wooden telescopes was so enormous that he needed four servants to operate the wheels, ropes and pulleys”*

*“On the occasional clear, moonless night, Lord Rosse sat at the eyepiece, and sailed on a journey through the Universe”*

*“The telescope had become our vessel to explore the Universe”*

## **2 BIGGER IS BETTER**

*“How to do better? Think mirrors”*

*“An immense piece of cosmic artillery, ready to attack the Universe”*

*“The Hooker Telescope led scientists to one of the most profound discoveries of the twentieth century”*

*“Life is a miracle in an eternally evolving Universe”*

*“Hale had one final dream: to build a telescope twice as large as the previous record holder”*

## **3 TECHNOLOGY TO THE RESCUE**

*“Just as modern cars don’t look like Model T-Fords, current telescopes look very different from traditional instruments”*

*“Optical engineers use giant, rotating ovens to cast meniscus-shaped mirror shells that can be many metres wide but less than twenty centimetres thick*

*“Cathedrals of science, devoted to observing the heavens”*

**“By far the biggest astronomy machine ever built is the European Very Large Telescope”**

**“At Paranal, you are about as close to the Universe as you can be without leaving Earth”**

**“At sunset, the giant telescope enclosures open up, starlight rains down on the VLT mirrors and new discoveries are made”**

**“These giant telescopes have eyes as large as swimming pools”**

**“We’ve come quite a way since Galileo”**

## **4 FROM SILVER TO SILICON**

**“For well over two hundred years, astronomers also had to be artists”**

**“Photography came to the rescue”**

**“Astrophotography turned observational astronomy into a true science”**

**“Supernovae explode, new stars are born.”; Pulsars flash, gamma-ray bursts detonate and black holes accrete**

**“The LSST will open up a webcam window on the Universe”**

**“A few years from now, anyone will be able to explore the cosmos from a laptop computer”**

## **5 SEEING THE INVISIBLE**

**“Studying the Universe using visible light alone is like attending a concert with a severe hearing problem ”**

**“ ALMA will be the largest — and highest — astronomical observatory ever built”**

**“These instruments look right through cold cosmic dust clouds, revealing newborn stars that would otherwise be invisible”**

**“ Trillions of neutrinos travel through your body every second ”**

**“ ‘Telescopes’ like LIGO are searching for tiny ripples in the very structure of spacetime ”**

## **6 BEYOND EARTH**

**“ Hubble has revolutionised every single field in astronomy ”**

**“Without space telescopes, astronomers would be blind to energetic forms of radiation ”**

**“Energetic radiation passes right through a conventional telescope mirror ”**

**“ Hot gas glows in X-rays, just before it plunges into the black hole and out of sight ”**

**“ WMAP gave cosmologists their best view yet of the birth of the Universe ”**

## **7 WHAT’S NEXT?**

**“Almost five hundred individual segments will make up one enormous mirror as tall as a seven-storey apartment”**

**“LOFAR will even look for possible radio signals from extraterrestrial civilisations ”**

**“ We can only speculate about the exciting discoveries Hubble’s successor will make ”**

**“ Radio astronomers want to put a LOFAR-like array of small antennas on the Moon ”**

**“ Mercury telescopes can only look straight up, but they’re relatively cheap and easy to build ”**

**“It’s hard to imagine that Earth is the only living planet in the entire Universe ”**

**“ Hundreds of thousands of amateur astronomers, all across the globe, go out every clear night to marvel at the cosmos”**

**Author’s Bios**

**Image credits**

## **EYES ON THE SKIES**

400 Years of Telescopic Discovery

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### **STAR-FORMING REGION S106 (INSIDE FRONT COVER)**

The Subaru Telescope on Mauna Kea produced this deep infrared image of the star-forming region S106. S106 is at a distance of approximately 2000 light-years from Earth. The hourglass appearance of S106 is the result of the way material is flowing outwards from the central star. This infrared image is very sharp and reveals subtle details like ripples inside the nebula.

### **PINWHEEL GALAXY (INSIDE BACK COVER)**

The Pinwheel Galaxy's giant spiral disc of stars, dust and gas is 170 000 light-years across or nearly twice the diameter of our Milky Way. The galaxy is estimated to contain at least one trillion stars. Approximately 100 billion of these stars alone might be like our Sun in terms of temperature and lifetime. The high resolution of the *Hubble Space Telescope* reveals millions of the galaxy's individual stars in this image.

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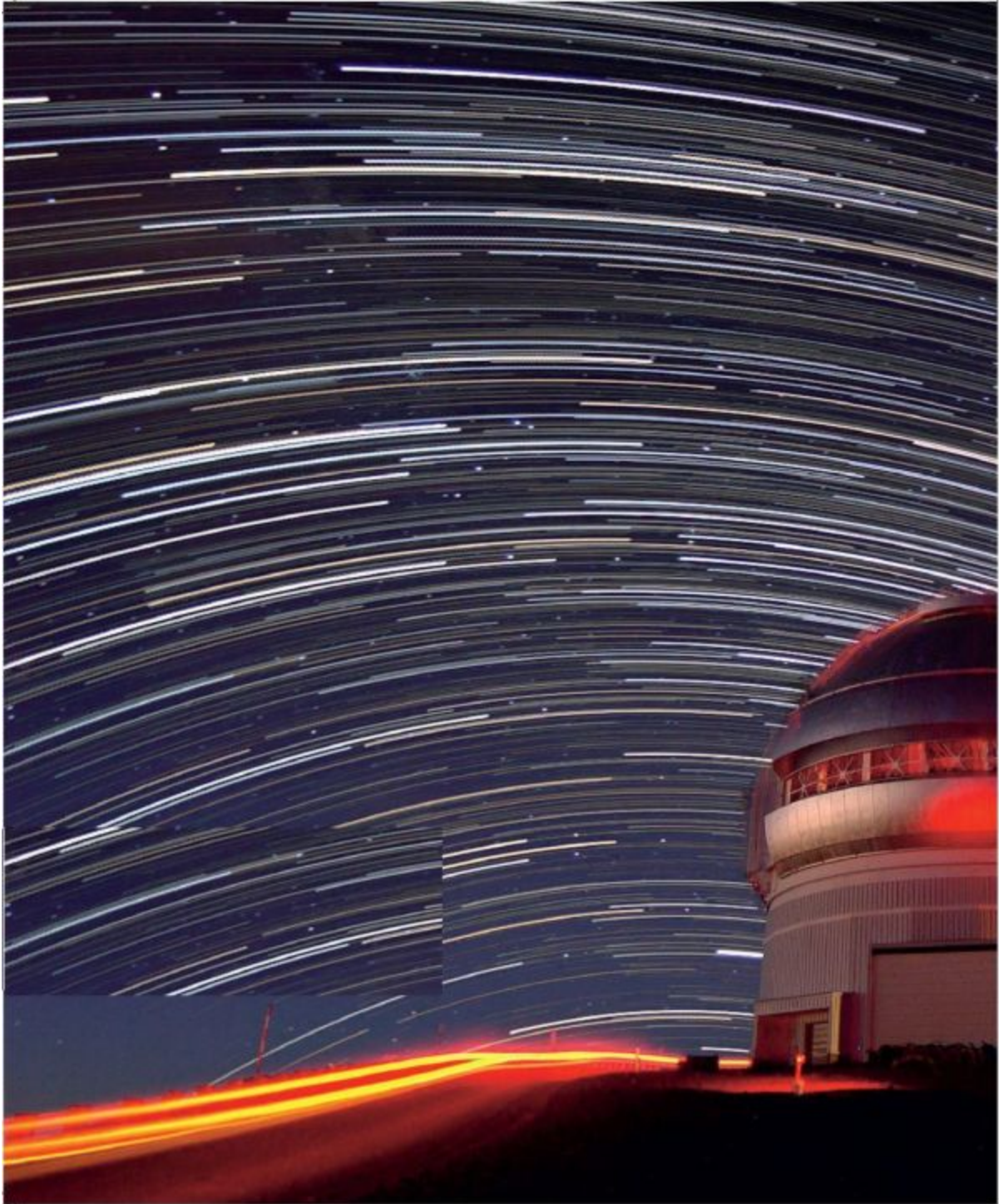
# EYES ON THE SKIES

400 Years of Telescopic Discovery



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**STAR TRAILS OVER GEMINI NORTH** Star trails majestically arch above the Gemini North Telescope in this long exposure, made on Mauna Kea. Light from the setting Moon is reflected from the right of the dome, while twilight provides a faint lingering glow on the left side. The centre of the dome shows the glow of a small red flashlight.



# ***FOREWORD***



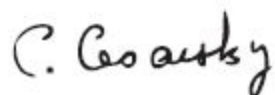
We believe that even our most remote ancestors looked up with wonder and awe at the night sky. But, 400 years ago, something entirely new happened: Galileo turned a homemade arrangement of magnifying glasses to the skies, taking advantage of information on advances in spyglasses made elsewhere in Europe. So Galileo was the first to see amazing phenomena: the mountains on the Moon, the phases of the planet Venus, the satellites of Jupiter, spots on the Sun... But the essential step taken by Galileo, the most important for us, as astronomers, is that he immediately tried to understand the meaning of what he saw, to translate the beautiful images into facts about the Earth and its position and motion with respect to the Sun; he recognised the Moon as a body akin to the Earth, and he realised that Jupiter and its satellites formed a miniature Solar System.

## **THE MAGNIFICENT STARBURST GALAXY MESSIER 82 — A MULTI- WAVELENGTH VIEW**

Three space telescopes capture the fireworks of the active galaxy Messier 82. X-ray data recorded by the Chandra X-Ray Observatory appears in blue and infrared light recorded by the Spitzer Space Telescope appears in red. Hydrogen emission detected by the Hubble Space Telescope appears in orange, while the galaxy's blue radiation, also imaged by Hubble, is displayed in yellow-green.

This happened just 400 years ago. Since then astronomers have been following in Galileo's footsteps, constantly improving telescopes and instruments, and trying to make sense of it all. The progress has been fantastic! Today, there are many optical telescopes with diameters in excess of eight metres all over the world, supplemented on the ground by radio telescopes and novel detectors of ultra high-energy particles and photons, while satellites pick up other kinds of radiation from the Universe. Space is expensive, but offers the ideal conditions for observations, even in the optical and the infrared, as can be seen from the unique results obtained by the modestly sized Hubble Space Telescope, which complement those of the giant Earth-bound telescopes. These new observations, and the interpretations and theories they have fostered, have not only revolutionised our view of the Solar System, but have turned the entire Universe, its origin, its evolution, the history of its components, gas clouds, galaxies and galaxy clusters, stars, planets in our Solar System and elsewhere, into objects of scientific study.

So, in 2009, in the International Year of Astronomy, we are celebrating Galileo's legacy and all the discoveries that have taken place in the intervening years, as well as the explosion of knowledge that we are witnessing now, made possible by new technologies. This book, written by two experienced and talented astronomy communicators, illustrates beautifully the saga of the telescope over 400 years, and the prodigious advances that have been made in understanding the Universe.



Catherine Cesarsky  
President of the International Astronomical Union & Director  
of Research, DSM/CEA-Saclay, France



# ***1***

## ***NEW VIEWS OF THE SKIES***

### **ARTIST'S IMPRESSION OF GALILEO'S FAMOUS TELESCOPES**

With his small, homemade telescopes, capable of magnifying objects by a factor of 20, Galileo Galilei made some of mankind's most astonishing discoveries. He observed stars and nebulae and studied Solar System objects like the Sun, the Moon, Saturn, Jupiter and Venus. Although he did not invent the instrument, it was Galileo who truly made the telescope famous.

The telescope is astronomy's miracle worker. It reveals faint stars and nebulae and magnifies distant objects. Telescopes take astronomers on a journey to the distant reaches of the Universe, where sparkling galaxies adorn the darkness of the void. But they also serve as time machines, providing scientists with a view of the earliest cosmic eras. No other single instrument has done so much for our view of mankind's place in time and space. Astronomy would barely rate as a science without the telescope. Four hundred years ago the early pioneers began a journey that led from the chance alignment of two simple lenses to today's complex space-based observatories and massive mountaintop mirrors.

**“That night Galileo started a  
scientific revolution of cosmic**

## **proportions”**

Four centuries ago a man walked out into the fields near his home in Padua and pointed his homemade telescope at the Moon, the planets and the stars. Astronomy would never be the same again. The date was Thursday, 30 November 1609. The man was the Tuscan physicist and astronomer Galileo Galilei. He may not have realised it at the time, but that night he started a scientific revolution of cosmic proportions. To commemorate Galileo's first observations of the heavens with a telescope the United Nations and the International Astronomical Union have declared 2009 to be the International Year of Astronomy.

For thousands of years the human eye was the only instrument available to observe the Universe. The invention of the telescope changed that. Now astronomers assemble giant mirrors on remote mountaintops to look out through the thinnest layers of the clearest, stillest atmosphere to catch faint signals from some of the farthest and oldest objects known. Radio telescopes collect faint chirps and whispers from outer space. Scientists have even launched telescopes into Earth orbit, high above the distorting effects of our atmosphere. And the view has been breathtaking.

Galileo didn't invent the telescope, and its exact origin is still controversial. The oldest existing documents to mention the telescope attribute its invention to the Dutch spectacle maker, Hans Lipperhey (also known as Lippershey) in the early 17th century. Tinkering away, Lipperhey found that placing a convex lens at one end of a cardboard tube and a concave lens at the other allowed him to magnify distant objects. The telescope was born!

**“The true origin of the telescope remains shrouded in**