is writ large as the wavefunctions approach macroscopic, millimetre size. One can also think of condensates as being laser-like sources of matter waves, all the atoms having the same wave nature and state of motion. They are coherent matter wave sources or 'atom lasers' in the same sense that ordinary lasers are coherent sources of light wave photons. Because of these unique properties as macroscopic quantum systems, they are finding applications in such diverse areas of science as superfluidity, quantum computing and precision measurements based on atom interferometry.

Bose–Einstein condensates were first formed in the laboratory in 1995 by using evaporative cooling of gases to temperatures in the nanokelvin range. This work opened the door to a wide range of new physics. The pace of advances has been quite breathtaking, with studies of the physical properties of the condensates and, most recently, the prospect of their use in quantum-computational schemes. The 2001 Nobel Prize was awarded to Carl Wieman, Eric Cornell and Wolfgang Ketterle for their spectacular achievements in this field. Although progress continues at a cracking pace, there is now a set of basic notions that it is sensible to teach postgraduates, including the way that condensates are made and their physical properties as macroscopic quantum systems. This book is an excellent source of information on this topic, and is accessible to a wide range of physicists and chemists.

Previous accounts of Bose–Einstein condensation are scattered among various papers and review articles. Older texts that deal with the physics of Bose gases or superfluids cover some of the issues but deal with matters that are relevant to the new experimental scene in a cursory manner. So this is a most welcome text for those of us wishing to expound the new physics to a younger generation of physicists. The range of topics and level of detail is well matched to the needs of someone with little background in atomic or optical physics. Topics covered include the microscopic theory of trapped condensates and their superfluid properties, excitations and vortices. The authors have also included problems at the end of each chapter, enhancing the book's value as a teaching aid.

It is inevitable in such a rapidly moving field that the book does not contain information on the most recent advances concerning Bose–Einstein condensation in lattices, quantum phase transitions and quantum information processing (for reviews see *Nature* **416,** 205–246; 2002). These will probably be in the next edition of what is likely to be a best seller in its category. This well-produced book is a 'must buy' for anyone wanting to get started in this field. ■

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Science in culture

Projecting an image

Did the Old Masters paint using optical projection techniques?

Michael John Gorman

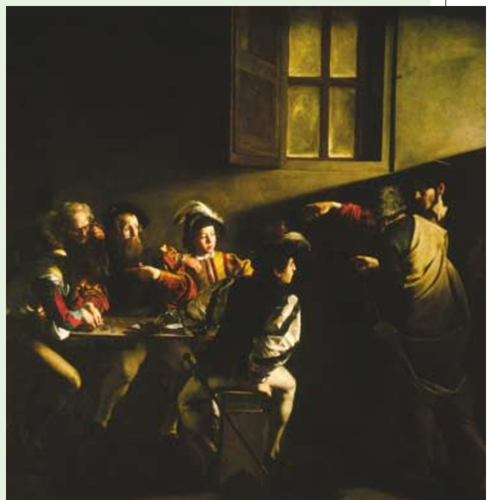
Painters from Jan van Eyck to Jean-Auguste-Dominique Ingres may have achieved a remarkable imitation of nature not through sheer painterly talent, but by using optical devices, according to David Hockney's controversial recent book *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters* (Penguin Putnam, 2001). Specifically, Hockney, assisted by optical scientist Charles Falco of the University of Arizona, argues that from around 1430 many painters used a concave mirror to project brightly lit subjects onto a canvas, allowing them to render figures with unprecedented naturalism. Later, at around the end of the sixteenth century, according to Hockney and Falco, painters including Caravaggio began to use refractive lenses instead of concave mirrors to project their images for tracing (see *Nature* **412,** 860; 2001).

Since the publication of Hockney's provocative thesis, several objections have been raised. For example, it has been claimed that Hockney's projection technique would have required a mirror of very long focal length to create an image suitable for tracing, and that this would exceeded the technical capabilities of Renaissance mirror-makers.

New evidence concerning the history of optical projection further challenges Hockney's hypothesis. In particular, a close reading of the historical documents suggests that the specific device that Hockney and Falco claim was used widely by artists from the 1430s was in fact invented by the Neapolitan magician Giambattista della Porta in 1558, and then rendered obsolete by della Porta himself in 1589.

Della Porta was as famous for his investigations of arcane natural processes and mechanical contrivances as for being a playwright and impresario. One of the many instruments that intrigued him was the camera obscura — the generic name given to the projection of inverted images through a small hole into a darkened chamber. In 1558, he gave the earliest description of a new type of camera obscura in the first edition of his widely read book *Natural Magic*. The new technique involved using a concave mirror to project an inverted image onto a piece of paper. This is the first documented account of the device that Hockney and Falco claim was used by artists from the 1430s.

Incidentally, the first account of incorporating a convex lens into the camera obscura dates from just eight years earlier, in the encyclopedic work of the astrologer and mathematician Girolamo Cardano called *On Subtlety*, which also describes in detail the workshop techniques of contemporary painters.



Caravaggio may have used della Porta's camera obscura when painting *The Calling of St Matthew*.

ARALDO DE LUCA/CORBIS

In the expanded second edition of *Natural Magic*, published in 1589, della Porta added a dramatic revision to his concave-mirror camera obscura. As a result of his extensive investigations of optical instrumentation on the Venetian glass-making island of Murano in 1580, he combined a convex lens with the concave-mirror projection system. The remarkable result was a device that projected large, upright images. The inverted image formed by the lens, falling a short distance in front of the focal point of the concave mirror, served as an object for the concave mirror, which turned it upright and magnified it. In this way, even a concave mirror of short focal length, within the manufacturing capabilities of the late sixteenth century, could be used to project life-sized images into a darkened room, given an appropriate lens. Della Porta used this device, which doubled as a primitive reflecting telescope, not to paint but to project extravagant theatrical performances for aristocratic audiences seated in his darkened chambers.

Where does this leave the earlier paintings discussed in Hockney's book? At best, the device that Hockney claims was used by artists from the 1430s had perhaps a 35-year working life as an artist's instrument over 100 years later, assuming that it was not just an amusing toy for those unable to draw, as della Porta himself suggests. If Caravaggio used a camera obscura, he would have had every opportunity to avail himself of the latest technology — della Porta's combined convex lens and concave mirror, an instrument that goes unmentioned in Hockney's book. If fifteenth-century painters ever used the camera obscura, however, then they used a simple hole in the wall: no mirror, no lens.

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http://www.stanford.edu/group/shl/eyes/hockney