Francesco Maria Grimaldi | Encyclopedia.com

Complete Dictionary of Scientific Biography COPYRIGHT 2008 Charles Scribner's Sons
14-18 minutes

(*b*. Bologna, Italy, 2 April 1618; *d*. Bologna, 28 December 1663)

astronomy, optics.

His father, Paride Grimaldi, a silk merchant and member of a wealthy family of noble blood, settled in Bologna in 1589. Paride's first wife died childless, and, about 1614, he married Anna Cattani (or Cattanei). Of her six sons five survived; Francesco Maria was the fourth born, the third surviving. With his father deceased and his mother in possession of her grandfather's chemist's shop, Francesco Maria and his brother Vincenzo Maria, one year older, entered the Society of Jesus on 18 March 1632. Of Francesco's first three years in the notivitate, it is known that the third was spent at Novellara. Following this he went to Parma in 1635 to begin studying philosophy. Within a year that house was closed, and he was transferred to Bologna.

In 1636 he went to Ferrara for the second year of his three-year course in philosophy, while the third year, 1637-1638, was spent in Bologna again. From 1638 to 1642 Grimaldi taught rhetoric and humanities in the College of Santa Lucia at Bologna. From 1642 to 1645 he studied theology. Further study in philosophy brought him a doctorate in 1647, and he was then appointed to teach philosophy. Within a year, however, consumption undermined his health, making it necessary for him to transfer to a less timeconsuming task, the teaching of mathematics. According to Riccioli Grimaldi was well prepared to teach all branches of mathematics—geometry, optics, gnomonics, statics, geography, astronomy, and celestial mechanics. By 1651 he had determined to take the full vows for priesthood and did so on 1 May.

During the 1640's and especially in the 1650's Grimaldi was very active in astronomical and related studies. From 1655 to the end of his life his scientific efforts were devoted essentially to the preparation of *De lumine*. His death came shortly after finishing this work, at the end of an eight-day illness characterized by high fever and headaches.

The astronomical work of Grimaldi was closely tied to the career and interests of Giovanni Battista. Riccioli (1592–1671), a Jesuit since 1614, who taught theology for a long time before gaining permission to pursue his love of astronomy. Riccioli was perfect of studies at Bologna and had been dispensed from all teaching in order to prepare his *Almagestum novum* when Grimaldi came under his influence. In 1640 Grimaldi conducted experiments on free fall for Riccioli, dropping weights from the Asinelli tower and using a pendulum as timer. He found that the square of the time is proportional to the distance of free fall from rest. Riccioli credited him as being absolutely essential to the completion, in 1651, of *Almagestum novum*, build, nd operate new observational instruments. devise build, and operate new observational instruments. Grimaldi's contributions included such measurements as the heights of lunar mountains and the height of cloups. He is responsible for the practice of naming lunar regions after astronomers and physicists.

An especially noteworthy contribution was his selenograph of the moon, a composite from telescopic observations of many phases, accurate and correct enough so that he must have used crossed hairs and a micrometer with his eyepiece. The use of a micrometer eyepiece seems also to have been made in the triangulation and leveling proceducers carried out to establish the meridian line for Bologna. In this project, completed by 1655, Riccioli and Grimaldi collaborated with Montalbini and G. D. Cassini. The results were reported in Riccioli's *Geographiae Hydrographiae Reformatae* (1661). Grimaldi appears to have been responsible for much of the tabular material in the second volume of Riccioli's *Astronomia Reformata* (1665), especially on the fixed stars.

Grimaldi's primary contribution to positive science was the discovery of optical diffraction. A comprehensive treatise on light, the complete descriptive title is *A physicomathematical thesis on light, colors, the rainbow and other related topics in two books, the first of which adduces new experiments and reasons deduced from them in favor of the substantiality of light. In the second, however, the arguments adduced in the first book are refuted and the Peripatetic teaching of the accidentality of light is upheld as probable*. The title page also states that he deals with "the previously unknown diffusion of light; the manner and causes of reflection, refraction, and diffraction; vision and the intentional species of visibles and audibles; the substantial effluvium of the magnet, which pervades all bodies; and in a special argument the atomists are attacked." A final descriptive element appears on the subtitle page preceding book II, where he notes that, in any case, "permanent colors are nothing other than light." If we take Grimaldi at his word, he is presenting two possible basic theses about the nature of light. It may be substance, or it may be accident, i.e., a quality of some other substance. His personal choice appears in his preface to the work, where he says he would be delighted by a student who would be persuaded that the experiments supporting the substantiality of light have no force and who could confirm better than he "the doctrine which we personally embrace and finally sustain in the present opuscule." At various places in book I he prescinds from a substantial theory of light in arguing a proposition e.g., prop. 10, which deals with the nature of the propagation of light. His position in book I is thus not always in support of the substantial theory of light. As a philosopher he stands against the certainty of either hypothesis, each called an “opinion,” on the nature of light. He says ultimately that the many experiments of book I, albeit persuasive, “do not in any way lead to the substantiality of light”.(II, 2)

Grimaldi’s position on the substance-accident question is better understood by a look at the whole book and what it deals with. Book I (sixty propositions, 472 pages) devotes the first twenty-seven propositions (229 pages) essentially to the four modes of light, the porous nature of bodies, and the propagation of light. Thereafter book I deals with colors and the rainbow (props. 28-60, 244 pages). The substance accident question is not much debated after prop. 27, nor is it made a necessary basis for the treatment of colors and the rainbow. While books I and II present opposing views on the substantial nature of light, they agree on other major points. In both books Grimaldi opposes any corpuscular theory of light. In both books he is concerned to show color to be nothing more than a modification of light. Color is not the addition of something else to light. Both books agree on the fluid nature of light phenomena. Light may be a fluid substance or the accidents of some other fluid substance(s). Grimaldi expressly chooses the latter version of fluid theory.

The discussion of diffraction (book I, prop. 1, pp. 1-11) is the basis for introducing a fluid, but not necessarily substantial, view of light. The experiments on diffraction are clear and well described by Grimaldi. He used bright sunlight introduced into a completely darkened room via a hole about 1/60 inch across. The cone of light thus produced was projected to a white screen at an angle so as to form an elliptical image of the sun on the screen. At a distance of ten to twenty feet from the slit he inserted a narrow opaque rod into the cone of light to cast a shadow on the screen. The border of this shadow, he noted, is not clear, and the size of the shadow is far beyond what rectilinear projection would predict. Having demonstrated this, he proceeded to his description of external diffraction bands. These bands are never more than three, and they increase in intensity and in width nearer to the shadow. The series of bands nearest the shadow has a wide central band of white with a narrow violet band nearer the shadow and a narrow red band away from the shadow. Grimaldi warned that there and violet bands must be observed closely to avoid mistaking the series for alternating bands of light and dark. After describing these parallel bands, he turned to examine the effect of varying the shape of the opaque object. In place of the rod he used a step-shaped object to cast a shadow with two rectangular corners. Still describing external bands, he carefully described the curvature of the bands around the outer corner and continuing to follow the shadow border. When the series approaches parallel to the other side of this corner. He noted that as they cross each other the colors “are either augmented intensively or are mixed.” Nothing more about the appearance of these intersecting bands is found in the description.

In the diffraction experiments he now turned to a description of internal fringes. Here he omitted naming the colors or their order. His diagram shows two pairs of twin contiguous tracks following the border of an L-shaped shadow. These bands are said to appear only in pairs, while the number increases with the width of the obstacle and its distance from the screen. The bands bend around in a semicircle at the end of the L, remaining continuous. At the corner of the L he made a further observation. Here not only do the bands curve around to follow the shadow outline, but a shorter and brighter series of colors appears. He showed these as five feather-shaped fringes radiating from the inside corner of the L and perpendicularly crossing the previously described internal paired tracks of light. The nature of this phenomenon seems to have impressed him as being like the wash of a moving ship.

The final diffraction experiment allowed a cone of light to pass first through two parallel orifices, the first being 1/60 inch and the second being 1/10 inch in diameter. The distances between the holes and between the screen and second hole are equal, at least twelve feet each. The screen is parallel to the orifices. The screen holds a circle of direct illumination just over 1/5 inch across. The circle is significantly wider than rectilinear propagation allows and the border is colored red in part, blue in part. Neither the width nor order of these colors is given.

These diffraction experiments showed Grimaldi that a new mode of transmission of light had been discovered and that this mode contradicts the notion of an exclusively rectilinear passage of light. Diffraction thus gave prima facie evidence for a fluid nature of light. The name “diffraction” comes from the loss of uniformity observed in the flow of a stream of water as it “splits apart” around a slender obstacle placed in its path. He discussed other fluid phenomena analogously with light. To explain color and the varieties of color he decided that a “change in agitation” of the luminous flow is responsible. A light ray is conceived like a column of fluid in vibration, but not regular vibration. Lighter colors are said to result from a greater density of rays and darker colors from a lower density.

In performing his diffraction experiments, Grimaldi gives measurements only where they will show the nonrectilinear propagation of light. No quantities are given for the sizes or distances of the colored fringes in any of his experiments. No notion of periodicity occurred to him.

Knowledge of his work appears in the work of both Hooke and Newton. Hooke performed his first series of diffraction experiments later in 1672, after the notice of Grimaldi’s book in the *Philosophical Transactions*. Hooke referred to it, however, as inflexion and may have encountered diffraction phenomena independently. Newton was aware of Grimaldi’s work, but only at secondhand, crediting Honoré Fabri as the source of his knowledge on diffraction. At first (1675) Newton described and attempted to account for only the internal fringes. His description shows that he could not have performed the experiment. By 1686 he came to deny the existence of internal fringes on the basis of experiments. In the *Opticks* he described and tried to explain only the external fringes, which he never ceased to regard as a sort of refraction. The essence of Newton’s contribution to the knowledge of diffraction is his set of careful measurements, which made clear the periodic nature of the phenomenon.

BIBLIOGRAPHY

I. Original Works. The sole work published under Grimaldi's name or written by him is the posthumous *Physico-mathesis de lumine, coloribus, et iride, aliisque adnexis libri duo, in quorum primo asseruntur nova experimenta, & rationes ab iis deductae pro substantialitate luminis. In secundo autem dissolvuntur argumenta in primo adducta, et probabiliter sustineri posse docetur sentential peripatetica de accidentalitate luminis. Qua occasione de hactenus incognita luminis diffusione, de reflexionis, refractionis, ac diffractionis modo et causis, de visione, deque speciebus intentionalibus visibilium et audibilium, ac de substantiali magnetis efluvio omnia corpora pervadente, non pauca scitu digna proferuntur, et speciale etiam argumento impugnantur atomistae* (Bologna, 1665).

II. Secondry Literature. The sources for Grimaldi's life and personality are minimal. A brief elogium by Giovanni Battist Riccioli is appended to the printed text of Grimaldi's book. Riccioli is also responsible for detailed information on Grimaldi's family in an "Epitome genealogiae Grimaldae gentis," in *Almagestum novum, astronomiani veterum novumque*, **I** , pt. 2 (Bologna, 1651). A useful biography appears in Angelo Fabrioni, *Vitae Italorum*, III (Pisa, 1779), 373–381.

Other sources with significant amounts of information are the brief (none as long as thirty pages) publications of Roberto Savelli, *Grimaldi e la rifrazione* (Bologna, 1951) and *Nel terzo centenario del "De lumine" di F. M. Grimaldi* (Ferrara, 1966); and esp. of Giorgio Tabarroni, *P. F. M. Grimaldi Bolognese iniziatore della ottica-fisica* (Bologna, 1964) and *Nel terzo contenario della morte de F. M. Grimaldi* (Bologna, 1964).

The best account of his astronomical work is the *Almagestum novum*, which indicates some forty items of which Grimaldi was the source. Jiri Marek, "Les notions de la théorie ondulatoire de la lumière chez Grimaldi et Huyghens," in *Acta historiae rerum naturalium necnon technicarum*, I (1965), 131–147, is too eager to attribute ideas to Grimalid that are not his. The review of *De lumine* cited in the text is *Philosophical Transactions of the Royal Society of London*, **6** , no. 79 (22 Jan. 1672), 3068–3070.

By far the most useful discussion to date of Grimaldi and his work is Francis A. McGrath, "Grimaldi's Fluid Theory of Light," M.Sc. diss.(University College, London, 1969).

For the importance of Grimaldi's work to Newton, see Roger H. Stuewer, "A Critical Analysis of Newton's Work on Diffraction," in *Isis*, **61** (1970), 188–205.

Bruce S. Eastwood