

EDWARD CHARLES PICKERING (1846-1919) E A NOVA ASTRONOMIA

Pedro Ré

<http://www.astrosurf.com/re>

Edward Charles Pickering (Figura 1) nasceu em Boston no dia 19 de Julho de 1846. Completou os estudos universitários com 19 anos (Lawrence Scientific School, Harvard University) e dois anos depois é nomeado Professor de Física e de Matemática (Massachusetts Institute of Technology). Em 1869, com apenas 23 anos de idade, funda o primeiro laboratório de Física nos Estados Unidos da América. Durante cerca de 10 anos, Pickering publica mais de quarenta trabalhos (alguns em co-autoria com diversos alunos) e um manual pioneiro intitulado "Physical Manipulations". Este manual foi considerado na altura como um marco muito importante no ensino universitário da Física.



Figura 1- Edward Charles Pickering (ca. 1918) (esquerda), observatório de Harvard (ca. 1900) (centro) e refractor de 15" (direita).

Em 1869 e 1870, Pickering participa em duas expedições organizadas respectivamente pelo "Nautical Almanac" e "U.S. Coast Survey" para a observação de eclipses totais do Sol. Em 1877 assume a direcção do observatório de Harvard (cargo que ocupou ininterruptamente durante 42 anos) (Figura 1). A nomeação de um Físico como director do observatório motivou críticas por parte de alguns astrónomos. Pickering cedo compreendeu que as actividades do observatório deveriam centrar-se na "nova astronomia". Descreve de um modo sucinto as suas prioridades em três princípios e algumas linhas de acção:

"First, that it is primarily an institution for research. While a certain amount of teaching has been done, care has always been taken that it should not interfere with the main work of the institution. A second principle maintained has been the special advancement of the physical side of astronomy. While precise measurements of position have not been neglected, the policy has been rather to undertake such studies if the physical properties of the stars as would not be likely to be made at other observatories, and thirdly, the undertaking of large pieces of routine work, and the employment of numbers of inexpensive assistants whose work is in a great measure mechanical, such as copying and routine computing. This involves repetition of the work many hundreds, or even thousands, of times and renders it necessary that the observers and computers shall continue for years upon work of the same character".

Efectua uma revisão crítica do trabalho desenvolvido por outras Instituições e as suas primeiras prioridades foram centradas no campo da fotometria de estrelas:

“Photometry offers a field almost wholly unexplored with large telescopes”.

O observatório de Harvard em 1877 possuía dois instrumentos de elevada qualidade: um refractor de 15” (38 cm) (Figura 1) e um círculo meridiano de 8” (20 cm). Pickering desenvolve um extenso programa de observações fotométricas visuais. Inventa um novo tipo de instrumento (“meridian photometer”) que aplica ao refractor de 15”. Clark & Sons, constroem sob a sua orientação, diversos fotómetros (Pickering atribui letras do alfabeto a estes fotómetros de acordo com a ordem com que foram construídos).

Mede pela primeira vez a magnitude dos satélites de Marte (descobertos por Asaph Hall em 1877) bem como a magnitude da maioria das estrelas brilhantes visíveis do observatório de Harvard.

Entre os anos de 1879 e 1882, Pickering, auxiliado por Arthur Seale e Oliver C. Wendell, utiliza um fotómetro de 1,6” de abertura (fotómetro “P”) e em 1884 publica o seu primeiro estudo (“Harvard Photometry”) onde descreve o brilho de 4260 estrelas (até uma magnitude de 6). Entre os anos de 1882 e 1902, recorre à utilização de um fotómetro distinto (4”) na realização de mais de um milhão de estimativas fotométricas. Determina a magnitude de 60000 estrelas (magnitude limite de 9) e mais tarde recorrendo a um fotómetro de 12” estima o brilho de estrelas até uma magnitude de 12. Em 1906 as estimativas de magnitude no observatório de Harvard ascendiam a mais de 1,5 milhões, grande parte efectuadas por Pickering.

Pickering refere-se a este trabalho de rotina do seguinte modo:

“Although the work is the most acute and absolutely monotonous, I find it fascinating, and always watch the next morning for the progress made in the completion of the work”.

Algumas determinações fotométricas foram efectuadas várias vezes tendo sido atribuídas magnitudes distintas às mesmas estrelas. Pickering preparou um catálogo com 45000 estrelas (até a uma magnitude 6,5) que foi publicado em dois volumes nos Anais do Observatório de Harvard (“Revised Harvard Photometry”). Este trabalho constituiu uma referência essencial até à introdução recente da fotometria fotoelétrica.

A partir de 1883, Pickering realiza, com o auxílio do seu irmão William Henry Pickering (1858-1938), as primeiras experiências no domínio da fotografia astronómica. Em 1888 faz uma primeira tentativa com o intuito de estimar magnitudes estelares recorrendo a métodos fotográficos. Utilizou uma objectiva acromática (doblete acromático) com 8” (20 cm) de abertura (Vöigtlander) corrigido pela firma Clark & Sons (telescópio Bache). Com o auxílio deste astrógrafo, determina as magnitudes fotográficas de mais de 1000 estrelas na região do Pólo celeste Norte, 420 na região das Pleiades e mais de 1100 estrelas próximo do equador celeste. A maioria destas medições fotométricas foram efectuadas por Williamina Fleming (1857-1911).

Um outro projecto iniciado em 1883 foi o “Photographic Map of the Entire Sky”. Pickering pretendia registar fotograficamente as estrelas visíveis do observatório de Harvard (Hemisfério Norte) e na estação de Arequipa (Hemisfério Sul). Numa publicação do observatório (Circular nº 71) de 1903, descreve o trabalho desenvolvido:

“The collection of photographs at the Harvard College Observatory contains, in addition to the plates taken with the larger instruments, numerous photographs taken with two small anastigmatic lenses, each having an aperture of one inch, and a focal length of about thirteen

inches. A region of more than thirty degrees square is covered by a single eight by ten inch plate. With exposures of one hour, stars as faint as the twelfth magnitude are, in some cases, obtained. Owing to the scale of the plates, identification of the individual stars would become difficult if, by using longer exposures, the number of stars were increased. One of these lenses is mounted at Cambridge, and it is used principally for the northern stars. The other is similarly used for the southern stars at Arequipa. At each station two sets of photographs have been taken, the first having centers in declinations 0° , 30° , 60° , and 90° , and the second in declinations 15° , 45° , and 75° , the centers of the second set coinciding as nearly as possible with the corners of the first. An attempt has been made to cover all parts of the sky, not too near the Sun, at least twice each month, once each set. These photographs have proved unexpectedly useful here for determining the past as well as the present changes in light of variable stars, new stars, and similar objects”.

Este projecto é anterior à iniciativa “Carte du Ciel”. Pickering não concordou com a decisão tomada na primeira reunião organizada por Amédée Mouchez (1821-1892) em Paris em que foi adoptado com standard o refractor fotográfico idealizado pelos irmãos Henry (330 mm de abertura $f/10,4$). Em 1903 publica um Atlas que reunia 55 fotografias que cobria todo o céu ¹.

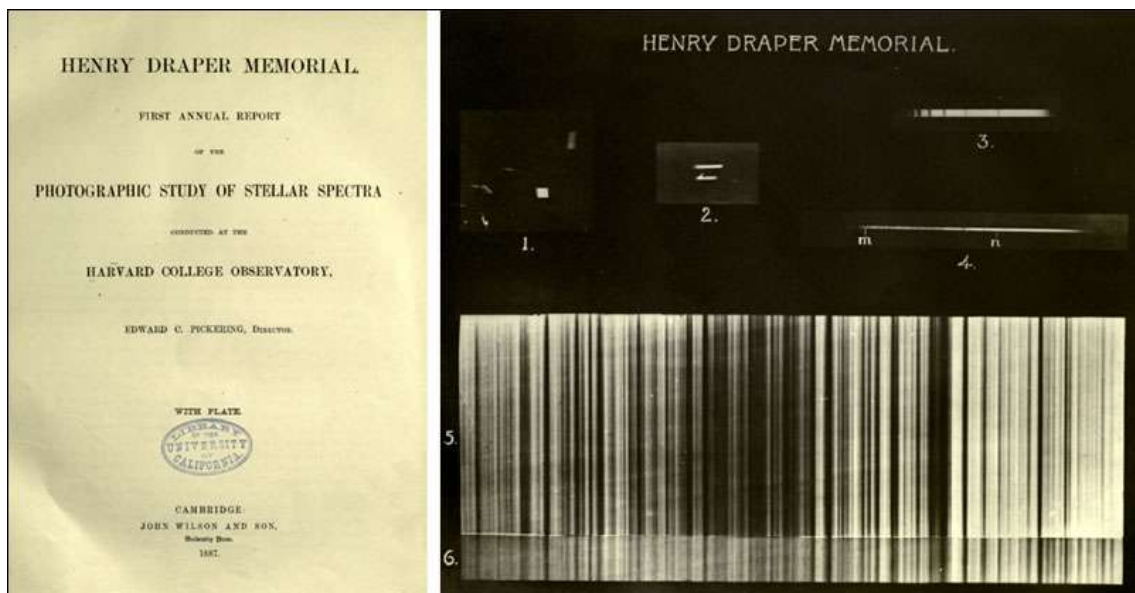


Figura 2- Henry Draper Memorial: Photographic Study of Stellar Spectra; Harvard College Observatory; First Annual Report (1887).

Pickering dedicou-se igualmente à espectroscopia. Entre os anos de 1878 e 1881 efectuou estudos espectroscópicos de nebulosas planetárias, estrelas vermelhas e estrelas com um espectro peculiar.

Consegue obter uma importante doação para financiar o registo fotográfico de espectros estelares. A viúva de Henry Draper (um dos primeiros astrónomos a fotografar espectros estelares) financia o projecto que é designado “Draper Memorial”. A primeira publicação deste projecto deu origem ao “Draper catalogue of stellar spectra” que surge em 1890. Este catálogo contém 28000 espectros obtidos a partir de mais de 10000 estrelas fotografadas com o telescópio de Bache.

¹ O projecto “Carte du Ciel” nunca foi terminado com sucesso apesar de se ter desenvolvido ao longo de mais de 60 anos.

No primeiro relatório anual do “Henry Draper Memorial”, Pickering descreve os instrumentos e os métodos utilizados:

“Dr. Henry Draper, in 1872, was the first to photograph the lines of a stellar spectrum. His investigations, pursued for many years with great skill and ingenuity, was most unfortunately interrupted in 1882 by his death. The recent advances in dry-plate photography have vastly increased our powers of dealing with this subject. Early in 1886, accordingly, Mrs. Draper made a liberal provision for carrying on this investigation at the Harvard College Observatory, as a memorial to her husband. The results attained are described below, and show that an opportunity is open for a very important and extensive investigation in this branch of astronomical physics (...) The instruments employed are a 8-inch Vöigtlander photographic lens reground by Alvan Clark and Sons, and Dr. Draper 11-inch photographic lens, for which Mrs. Draper has provided a new mounting and observatory. The 15-inch refractor belonging to the Harvard College Observatory has also been employed in various experiments with a slit spectroscope, and is again being used. Mrs. Draper has decided to send to Cambridge a 28-inch reflector and its mounting, and a 15-inch mirror, which is one of the most perfect reflectors constructed by Dr. Draper, and with which his photograph of the Moon has been taken. The first two instruments mentioned above have been kept at work during the first part of every clear night for several months (...) The spectra have been produced by placing in front of the telescope a large prism thus returning to the method originally employed by Fraunhofer in the first study of stellar spectra. Four 15° prisms have been constructed, the three largest having clear apertures of nearly eleven inches, and a fourth being somewhat smaller. The entire weight of these prisms exceeds a hundred pounds, and they fill a brass cubical box a foot in each side. The spectrum of a star formed by this apparatus is extremely narrow when the telescope is driven by clockwork in the usual way. A motion is accordingly given to the telescope slightly differing from that of the earth by means of a secondary clock controlling it electrically. The spectrum is thus spread into a band, having a width proportional to the time of exposure and to the rate of the controlling clock (...)”. (Figures 2 e 3).



Figura 3- Henry Draper Memorial: Photographic Study of Stellar Spectra; Harvard College Observatory; Second Annual Report (1888).

O catálogo completo (“Henry Draper Catalogue - HDC”) é publicado mais tarde por Annie Jump Cannon (1863-1941) e Pickering entre os anos de 1918 e 1924. Neste catálogo são descritas as classificações espectrais de 225300 estrelas. O HDC foi completado pelo “Henry Draper

Extention” publicado entre 1925 e 1936 que incluía a classificação espectral de 48850 estrelas e finalmente pelo “Henry Draper Extention Charts” publicado entre 1937 e 1949 com a classificação de mais 86933 estrelas.

O Henry Draper Catalogue introduz a classificação actual de espectros estelares, baseada no sistema inicialmente proposto por Secchi, subdividida num maior número de classes (agrupadas com as letras A a N): a classificação de Harvard. Annie Jump Cannon é a primeira a usar o sistema actual de classificação (O, B, A, F, G, K, M).

O estabelecimento de uma estação do observatório de Harvard no hemisfério Sul em Arequipa (Peru) desempenhou um papel fundamental em muitos destes estudos. A realização de numerosas fotografias astronómicas nesta estação, estudadas por Henrietta Leavitt (1868-1921) (Figura 4) resultaram na descoberta e na determinação dos períodos de numerosas estrelas variáveis nas duas núvens de Magalhães. Em 1908, H. Leavitt publica uma lista de 1777 variáveis (Cefeidas) e em 1912 descobre a relação entre o período destas variáveis e a sua magnitude absoluta, tornando deste modo pela primeira vez acessível a determinação da distância de objectos celestes.

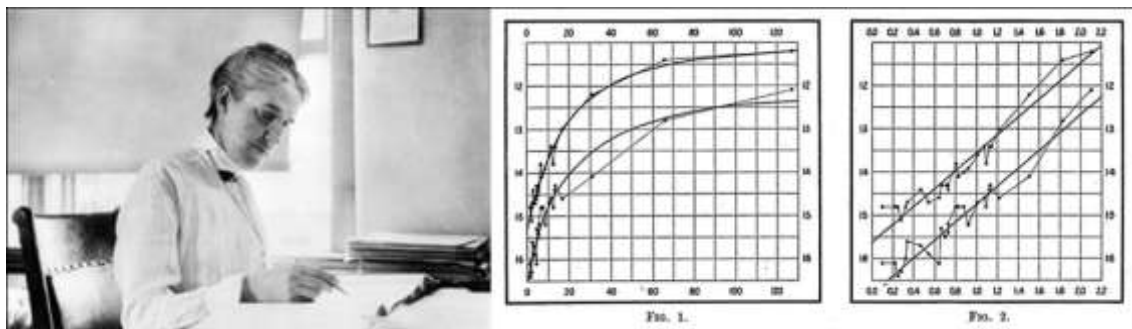


Figura 4- Henrietta Leavitt (1868-1921) (esquerda) e gráficos publicados em 1912 descrevendo a relação entre o período de 25 cefeidas e a sua magnitude absoluta.

Edward Charles Pickering foi um pioneiro da “nova astronomia” e um dos pioneiros da astrofotografia e da espectrografi. Numa publicação intitulada “The Future of Astronomy” (Popular Science Monthly, August 1909) Pickering sintetiza de um modo exemplar os novos desafios da astrofísica no início do século 20.

“It is claimed by astronomers that their science is not only the oldest, but that it is the most highly developed of the sciences. Indeed it should be so, since no other science has ever received such support from royalty, from the state and from the private individual. However this may be, there is no doubt that in recent years astronomers have had granted to them greater opportunities for carrying on large pieces of work than have been entrusted to men in any other department of pure science. One might expect that the practical results of a science like physics would appeal to the man who has made a vast fortune through some of its applications. The telephone, the electric transmission of power, wireless telegraphy and the submarine cable are instances of immense financial returns derived from the most abstruse principles of physics. Yet there are scarcely any physical laboratories devoted to research, or endowed with independent funds for this object, except those supported by the government. The endowment of astronomical observatories devoted to research, and not including that given for teaching, is estimated to amount to half a million dollars annually. Several of the larger observatories have an annual income of fifty thousand dollars (...) The practical value of astronomy in the past is easily established. Without it, international commerce on a large scale would have been impossible. Without the aid of astronomy, accurate boundaries of large

tracts of land could not have been defined and standard time would have been impossible. The work of the early astronomers was eminently practical, and appealed at once to everyone. This work has now been finished. We can compute the positions of the stars for years, almost for centuries, with all the accuracy needed for navigation, for determining time or for approximate boundaries of countries. The investigations now in progress at the greatest observatories have little, if any, value in dollars and cents. They appeal, however, to the far higher sense, the desire of the intellectual human being to determine the laws of nature, the construction of the material universe, and the properties of the heavenly bodies of which those known to exist far outnumber those that can be seen. Three great advances have been made in astronomy. First, the invention of the telescope, with which we commonly associate the name of Galileo, from the wonderful results he obtained with it. At that time there was practically no science in America, and for more than two centuries we failed to add materially to this invention. Half a century ago the genius of the members of one family, Alvan Clark and his two sons, placed America in the front rank not only in the construction, but in the possession, of the largest and most perfect telescopes ever made. It is not easy to secure the world's record in any subject. The Clarks constructed successively, the 18-inch lens for Chicago, the 26-inch for Washington, the 30-inch for Pulkowa, the 36-inch for Lick and the 40-inch for Yerkes. Each in turn was the largest yet made, and each time the Clarks were called upon to surpass the world's record, which they themselves had already established. Have we at length reached the limit in size? If we include reflectors, no, since we have mirrors of 60 inches aperture at Mt. Wilson and Cambridge, and a still larger one of 100 inches has been undertaken. It is more than doubtful, however, whether a further increase in size is a great advantage. Much more depends on other conditions, especially those of climate, the kind of work to be done and, more than all, the man behind the gun. The case is not unlike that of a battleship. Would a ship a thousand feet long always sink one of five hundred feet? It seems as if we had nearly reached the limit of size of telescopes, and as if we must hope for the next improvement in some other direction. The second great advance in astronomy originated in America, and was in an entirely different direction, the application of photography to the study of the stars. The first photographic image of a star was obtained in 1850, by George P. Bond, with the assistance of Mr. J.A. Whipple, at the Harvard College Observatory. A daguerreotype plate was placed at the focus of the 15-inch equatorial, at that time one of the two largest refracting telescopes in the world. An image of α Lyræ was thus obtained, and for this Mr. Bond received a gold medal at the first international exhibition, that at the Crystal Palace, in London, in 1851. In 1857, Mr. Bond, then Professor Bond, director of the Harvard Observatory, again took up the matter with collodion wet plates, and in three masterly papers showed the advantages of photography in many ways. The lack of sensitiveness of the wet plate was perhaps the only reason why its use progressed but slowly. Quarter of a century later, with the introduction of the dry plate and the gelatine film, a new start was made. These photographic plates were very sensitive, were easily handled, and indefinitely long exposures could be made with them. As a result, photography has superseded visual observations, in many departments of astronomy, and is now carrying them far beyond the limits that would have been deemed possible a few years ago. The third great advance in astronomy is in photographing the spectra of the stars. The first photograph showing the lines in a stellar spectrum was obtained by Dr. Henry Draper, of New York, in 1872. Sir William Huggins in 1863 had obtained an image of the spectrum of Sirius, on a photographic plate, but no lines were visible in it. In 1876 he again took up the subject, and, by an early publication, preceded Dr. Draper. When we consider the attention the photography of stellar spectra is receiving at the present time, in nearly all the great observatories in the world, it may well be regarded as the third great advance in astronomy”.

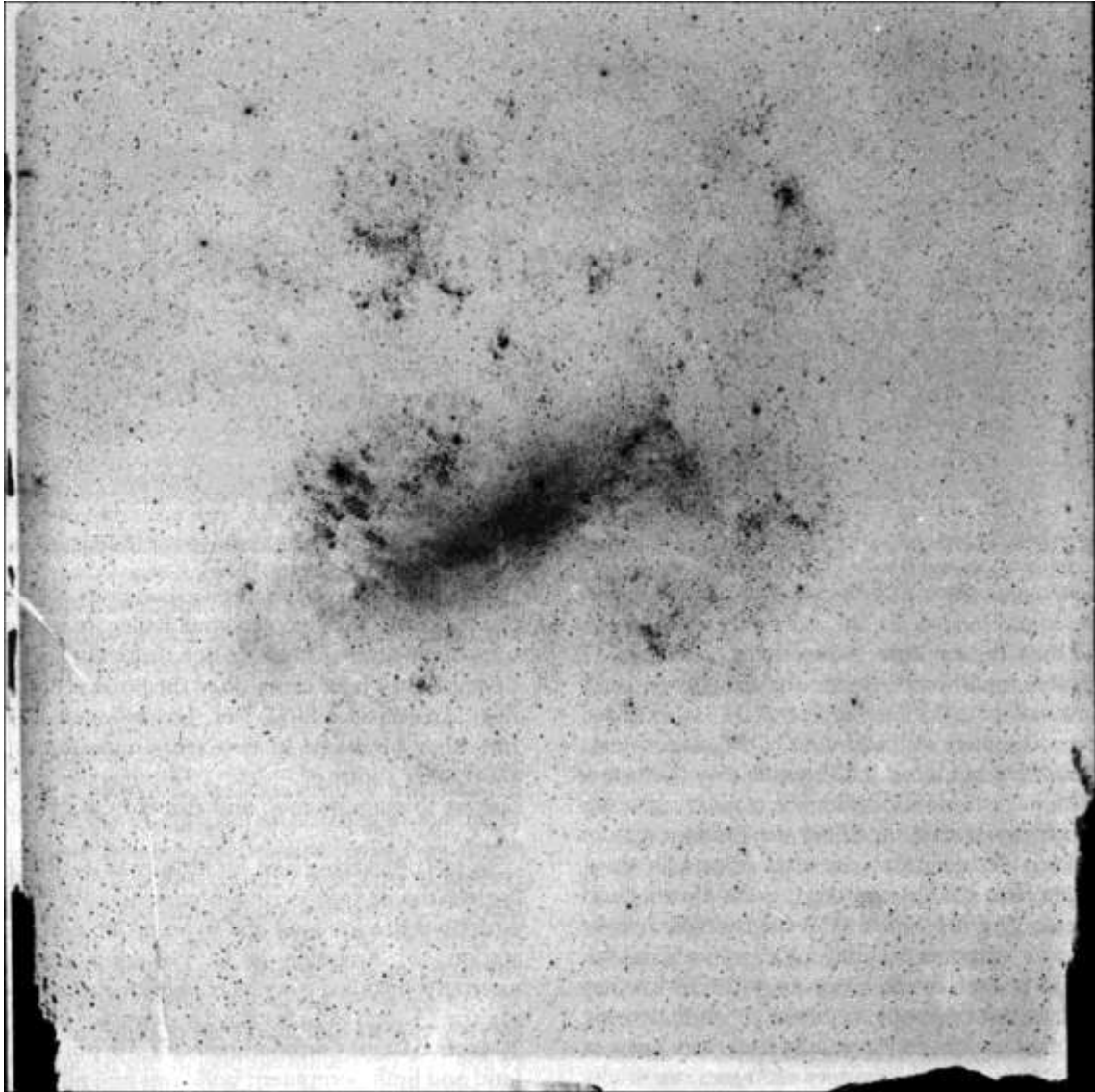


Figura 5- Fotografia da Grande Nuvem de Magalhães obtida em Novembro de 1897 com o auxílio do telescópio de Bache na estação de Arequipa do observatório de Harvard. Tempo de exposição: aproximadamente 7 horas.

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