2018 邵逸夫獎
The Shaw Prize 2018

邵逸夫獎獎章
The Shaw Prize medal

獎章正面是邵逸夫先生的肖像。背面刻上得獎年份、獎項類別、得獎者的姓名，並在右上方銘刻了戰國時代思想家荀子（公元前313至公元前238）的語句「制天命而用之」，意思是掌握和尊重自然規律，合理地用之。

The front of the medal displays a portrait of Mr Run Run Shaw, the founder of this award. On the reverse side, the medal shows the award category and year, the name of the laureate, and in the upper right corner, an imprint of a saying due to Xun Zi (313 – 238 B.C.E.), a thinker in the Warring States period of Chinese history: "制天命而用之", meaning "Grasp the law of nature and make use of it".

「邵逸夫獎」為國際性獎項，得獎者應仍從事於有關的學術領域，在學術研究、科學研究及應用上有傑出貢獻，或在近期獲得突破性的成果，或在其他領域有卓越之成就。評選的原則主要考慮候選人之專業貢獻能推動社會進步，提高人類生活質素，豐富人類精神文明。

「邵逸夫獎」設有三個獎項，分別為天文學獎、生命科學與醫學獎和數學科學獎，每項獎金一百二十萬美元。除獎金外，各得獎者還獲頒獎章及證書一份。提名及評審程序於每年九月開始，翌年夏季宣佈得獎人名單，並於同年秋季舉行頒獎典禮。

「邵逸夫獎」是按邵逸夫先生的意願而設，於2002年11月宣告成立，以表彰在學術及科學研究或應用上獲得突破成果，和該成果對人類生活產生意義深遠影響的科學家，原則是不論得獎者的種族、國籍、性別和宗教信仰。

「邵逸夫獎」由邵逸夫獎基金會管理及執行。各獎項的評審委員會由國際知名科學家組成，負責評審工作。

The Shaw Prize is an international award to honour individuals who are currently active in their respective fields and who have recently achieved distinguished and significant advances, who have made outstanding contributions in academic and scientific research or applications, or who in other domains have achieved excellence. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity's spiritual civilisation.

The Shaw Prize consists of three annual awards: the Prize in Astronomy, the Prize in Life Science and Medicine, and the Prize in Mathematical Sciences. Each prize carries a monetary award of one million two hundred thousand US dollars and each winner receives a medal and a certificate. The nomination process begins in September. The winners are announced in the summer and the prizes are presented in autumn in the following year.

Established under the auspices of Mr Run Run Shaw in November 2002, the Prize honours individuals, regardless of race, nationality, gender and religious belief, who have achieved significant breakthroughs in academic and scientific research or applications and whose work has resulted in a positive and profound impacts on mankind.

The Shaw Prize is managed and administered by The Shaw Prize Foundation based in Hong Kong. The important role of adjudication of candidates for the prizes is undertaken by an international team of reputable scientists who serve on the Selection Committees.

主辦
Presented by
康樂及文化事務署 Leisure and Cultural Services Department
THE SHAW PRIZE 邵逸夫獎 15TH ANNIVERSARY

籌劃
Organised by
香港科學館 HONG KONG SCIENCE MUSEUM
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教育局 Education Bureau
香港教育城 HKedCity

2018邵逸夫天文學獎
The Shaw Prize in Astronomy 2018

2018年度「邵逸夫天文學獎」頒予尚－盧·普吉 (Jean-Loup Puget) 以表彰他對紅外到亞毫米光譜範圍天文學的貢獻。他探測了在過去恒星形成過程中的星系所放出的宇宙遠紅外背景，並提出星際物質含有芳香族碳氫分子。通過普朗克太空計劃，他處理了星際物質前景的影響，因而顯著地提升了我們對宇宙學的認識。

The Shaw Prize in Astronomy 2018 is awarded to Jean-Loup Puget for his contributions to astronomy in the infrared to submillimetre spectral range. He detected the cosmic far-infrared background from past star-forming galaxies, and proposed aromatic hydrocarbon molecules as a constituent of interstellar matter. With the *Planck* space mission, he has dramatically advanced our knowledge of cosmology in the presence of interstellar matter foregrounds.

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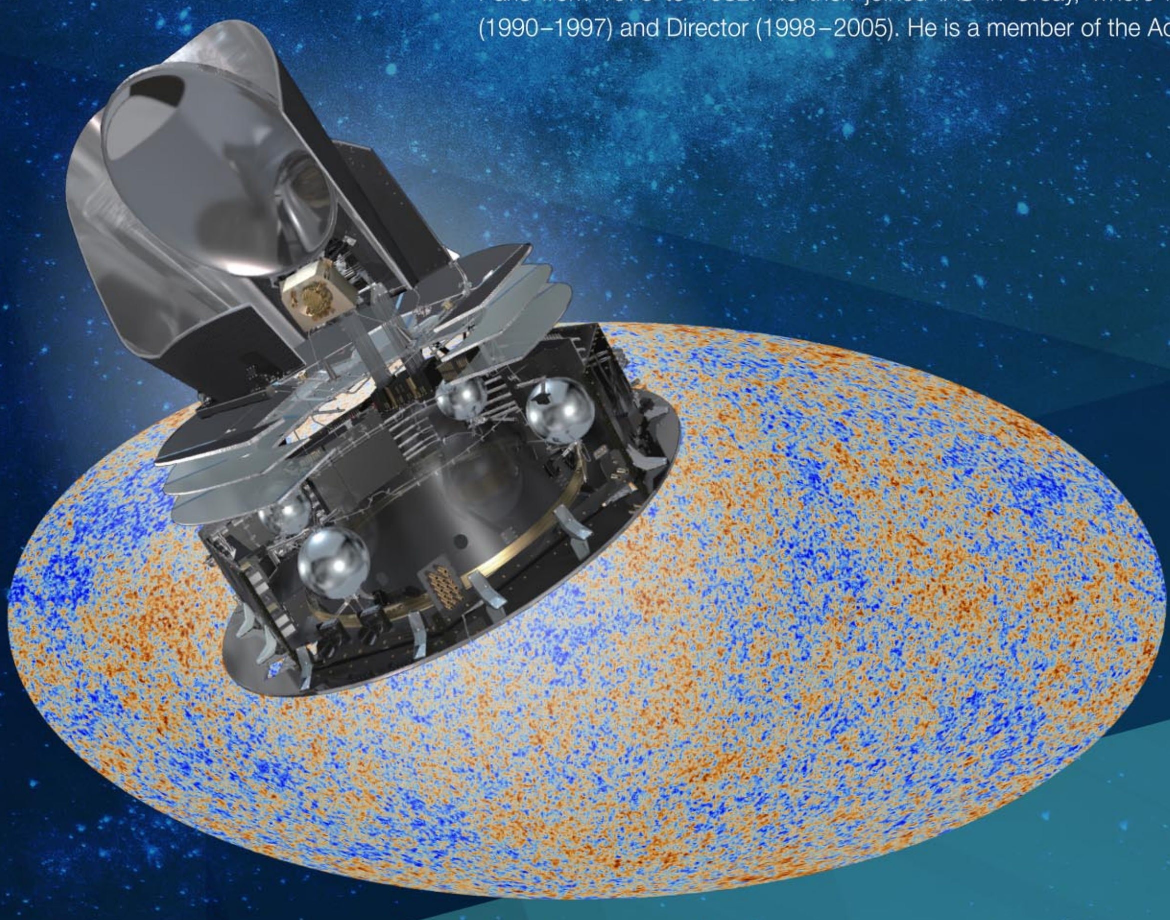
得獎人簡介
Biographical Note of Laureate

尚－盧·普吉 Jean-Loup Puget

尚－盧·普吉（Jean-Loup Puget）1947年於法國索恩盧瓦爾省索恩河畔出生，現為法國國家科學研究中心及法國巴黎－薩克雷大學奧賽太空天體物理研究所研究員暨歐洲太空總署普朗克計劃高頻儀器（HFI）首席研究員。1966年至1970年期間，他於法國卡尚高等師範學院進修，並於1973年於該校取得博士學位。畢業後，他加入法國國家科學研究中心擔任研究員及研究所所長。1978年至1982年於巴黎天體物理學研究所擔任副所長。之後加入奧賽太空天體物理研究所，先後擔任副所長（1990–1997）及所長（1998–2005）。他是法國科學院院士。

Jean-Loup Puget was born in 1947 in Chalon-sur-Saône, Saône-et-Loire, France and is currently a researcher at the Institut d'Astrophysique Spatiale (IAS) of CNRS and Université Paris-Saclay, France. He is also the Principal Investigator of the High Frequency Instrument (HFI) of the *Planck* Mission of the European Space Agency. He studied at Ecole normale supérieure de Cachan, France in 1966–1970 and received his PhD in 1973. From 1973, he was a Researcher and Director of Research at the National Center for Scientific Research in France. He served as Deputy Director of the Institute of Astrophysics of Paris from 1978 to 1982. He then joined IAS in Orsay, where he was successively Deputy Director (1990–1997) and Director (1998–2005). He is a member of the Académie des sciences (France).



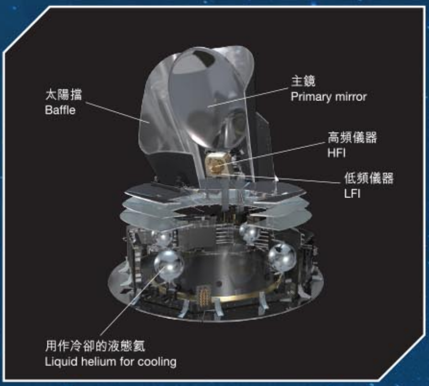
非凡貢獻
The Revolutionary Contribution

尚－盧·普吉對紅外至亞毫米光譜範圍的天文學作出了至為關鍵的貢獻，並透過普朗克計劃，精確量度宇宙微波背景，提高了我們在宇宙學的知識。

1984年，萊熱和普吉提出星際介質的一個主要成分，除了固體塵埃顆粒外，還有多環芳香族碳氫分子，從而解釋星際塵埃發出之前不明的紅外線光譜特徵。

1996年，遠紅外背景首次被普吉與研究團隊量度出來，這輻射是長久累積以來，由年輕星系中的微小塵粒放出。恆星誕生初期會釋放紫外線，塵粒吸收後被加熱，再放射出遠紅外線。

普吉在遠紅外、亞毫米、毫米天文學方面技術傑出、科學知識淵博，他進而領導歐洲太空總署(ESA)普朗克衛星高頻儀器(HFI)的發展和科學開發。2009年至2013年期間，普吉和他的國際團隊利用高頻儀器的新型低溫感應器，以超高靈敏度，測量宇宙微波背景，以及由銀河系的塵埃及氣體造成的前景輻射，觀測的範圍涵蓋350微米至3毫米。通過在這些短波段工作，高頻儀器所檢測到的宇宙微波背景，其角分辨率比任何利用其他方法取得的全天宇宙微波背景分佈圖優勝三倍。高頻儀器對前景塵埃輻射的敏感度也是獨一無二。在短波長範圍的輻射，主要就是由前景塵埃輻射造成。分離前景的能力對普朗克所要追求的結果非常重要，即極精確地測量出宇宙學參數 — 例如，暗物質的總密度測量精確度達2%。

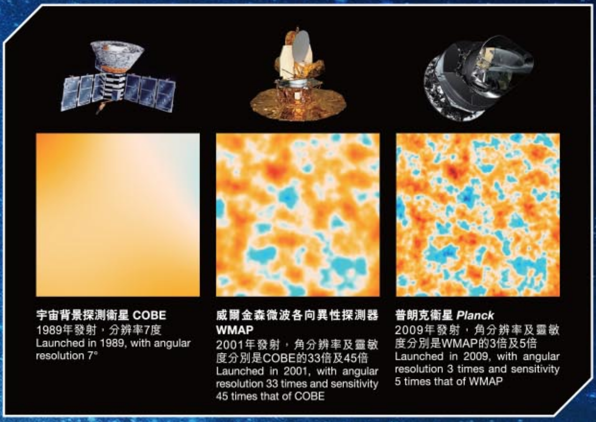


歐洲太空總署的普朗克衛星高4.2米，寬4.2米，主鏡口徑1.5米，配備兩套科學儀器：低頻儀器感應4至10毫米之間的輻射，而高頻儀器則量度0.3至3毫米之間的輻射。為了完成高敏感度測量，普朗克的感應器的溫度要冷卻至近乎絕對零度，否則它們散發的熱量將破壞測量結果。

The ESA's *Planck* spacecraft is approximately 4.2m high and 4.2m wide. The primary mirror is 1.5m and is accompanied by two science instruments: the Low Frequency Instrument (LFI), which measures radiation with wavelengths between 4mm and 10mm, and the High Frequency Instrument (HFI), which operates between 0.3mm and 3mm. To complete the highly sensitive measurements, *Planck*'s detectors were cooled to temperatures very close to absolute zero; otherwise their own emission of heat would spoil the measurements.

Jean-Loup Puget has made pivotal contributions to astronomy in the infrared to submillimetre spectral range and advanced our knowledge in cosmology through the precise measurement of the CMB by the *Planck* mission.

In 1984, Léger and Puget proposed the presence of polycyclic aromatic hydrocarbon molecules in addition to solid dust grains as a major constituent of the interstellar medium to explain the previously unidentified infrared emission features of interstellar dust.

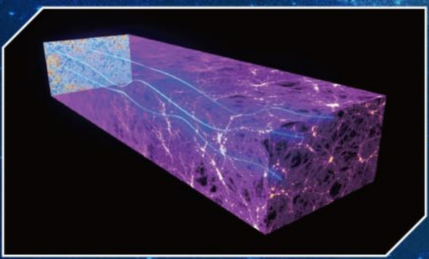


各個探測器所取得的宇宙微波背景比較

Comparison of Cosmic Microwave Background results from different probes

In 1996, Puget and the research team detected for the first time the far infrared background. This was given off when small dust grains in young galaxies absorbed ultraviolet radiation from forming stars, heated up and re-emitted in the far infrared, over the history of the Universe.

The culmination of Puget's work, building on his technical and scientific knowledge of far-infrared/submillimetre/millimetre astronomy, has been his leadership of the development and scientific exploitation of the High Frequency Instrument (HFI) on the *Planck* satellite of the European Space Agency (ESA). Between 2009 and 2013, Puget and his international team used HFI's novel cryogenic sensors to measure the CMB plus the foreground emission due to the Milky Way's dust and gas with superb sensitivity between 350 microns and 3 millimetres. By working at these short wavelengths, HFI has studied the CMB with an angular resolution three times better than any alternative all-sky CMB map. HFI is also uniquely sensitive to foreground dust emission, which dominates at short wavelengths. The ability to separate foregrounds was critical to the *Planck* results, which measure the cosmological parameters to exquisite precision — for example, the total density of dark matter is measured to 2% accuracy.

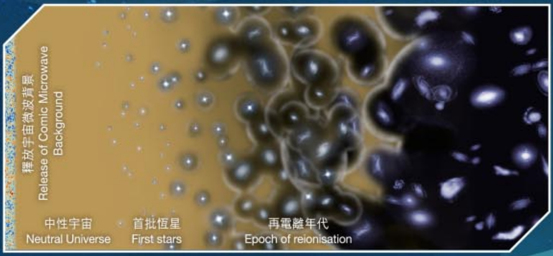


此圖顯示了宇宙微波背景中的光子穿越宇宙時，如何因大質量宇宙結構的引力透鏡效應而偏離方向。天文學家利用普朗克衛星的數據，首次能夠量度整個天空中的宇宙微波背景引力透鏡效應。

This illustration shows how photons in the Cosmic Microwave Background (CMB) are deflected by the gravitational lensing effect of massive cosmic structures as they travel across the Universe. Using data from *Planck* satellite, astronomers have been able to measure this gravitational lensing of the CMB over the whole sky for the first time.

現時，宇宙正在加速膨脹。如果愛因斯坦的相對論中重力理論是正確的話，便需要一個非零的真空能量密度來解釋。或者，膨脹加速顯示重力的大小在大尺度上須要修正，若然如是，宇宙中的密度起伏，便會以非標準的速度演化。普朗克計劃能夠驗證這種效應，因為宇宙微波背景輻射會受當中的質量起伏折彎。這種引力透鏡效應已被普朗克全面測繪，所得結果與標準引力理論的預言吻合。

Today, the Universe expands in an accelerating manner. If Einstein's relativistic theory of gravity is correct, this requires a non-zero vacuum energy density. Alternatively, the acceleration may indicate a modification of the strength of gravity on large scales, in which case density fluctuations in the Universe would develop at a non-standard rate. *Planck* can test for this effect, because the CMB radiation is deflected by intervening mass fluctuations. This gravitational lensing effect has been mapped comprehensively by *Planck*, and matches the expectations of standard gravity.



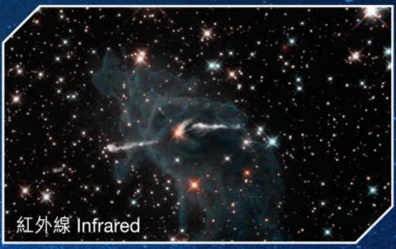
這代表着部分宇宙演化的時間。當首批恆星形成，它們發出的光電離中性原子，令原子還原為電子和質子，這個過程稱為宇宙再電離。普朗克數據顯示再電離的開始時間，較根據以往宇宙微波背景所推算要遲。

This ia an artist's impression of a portion in the timeline of the Universe. As the first stars came to life, they filled their surroundings with light, which subsequently split neutral atoms apart, turning them back into electrons and protons. This process is called cosmic reionisation. *Planck*'s data has demonstrated that reionisation started much later than any previous CMB data have suggested.

可見光以外
Light beyond the Visible

光，或稱為電磁波，其實遠超我們肉眼可見的範圍。肉眼可見的光，波長約在400到700納米之間（納米是百萬分之一毫米）。但是，有更多電磁波是我們看不到的。例如紅外線，它的波長較可見光稍長，由溫暖的物體發射。亞毫米波的波長為0.1-1毫米，新型的機場安檢設備會利用亞毫米波，因為它可以穿透衣服和皮膚，而不會穿透武器等物件。波長約10厘米的微波則可用於加熱食物，微波爐正是如此運作。

天體可以發出不同波長的輻射。較冷的物體發出輻射的波長往往較長，而較熱的物體，輻射的波長較短。絕對溫度只有數十至數百度的塵埃雲，在可見光波段黑似煤灰，但在紅外線波段則會十分明亮。紅外望遠鏡亦可以看穿阻擋可見光的塵埃和氣體雲，顯示背後的星星。宇宙則於不同方向非常均勻地發出波長約一毫米的微波。



紅外線下的船底座星雲可穿透氣體及塵埃，展示被遮蔽可能正產生噴流的初生恆星。
Infrared image of Carina Nebula penetrates the gas and dust and reveals the infant star that is probably blasting the jet.

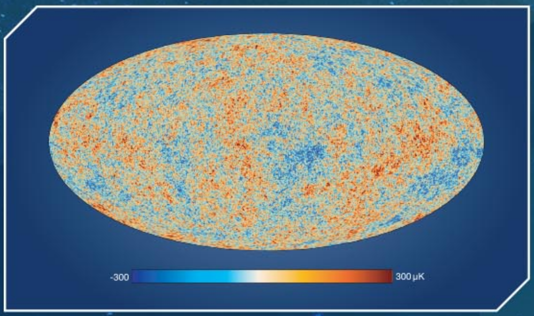
Light, or electromagnetic radiation, covers much more than what we see with our eyes. Our eyes can see light with a wavelength of between about 400 and 700 nanometres (a nanometre is a millionth of a millimetre). However, there are many other types of radiation which we do not see. For example, infrared radiation has a slightly longer wavelength, and is emitted by warm objects. Submillimetre radiation with a wavelength of 0.1 - 1 mm is used in modern airport security devices as it passes through clothes and skin, but not through objects such as weapons. Microwave with a wavelength of around 10 cm can be used to heat up food as in microwave ovens.

Celestial objects emit a whole range of radiations. The wavelength of the radiation tends to be longer for colder objects, and shorter for hotter objects. Clouds of dust with absolute temperatures that range from tens to hundreds of degrees appear as black soot in visible light, but glow brightly at infrared wavelengths. Infrared telescopes can also peer through clouds of dust and gas which block visible light, to reveal the stars behind. The Universe emits microwaves with wavelength of about 1 mm in all directions very uniformly.

宇宙微波背景
Cosmic Microwave Background

什麼東西發出這種幾乎完全均勻的微波輻射？根據大爆炸理論，宇宙起初是一個極小的奇點，然後膨脹138億年而形成今天的宇宙。宇宙形成之初溫度極高，它由等離子體組成。等離子體不斷發射又重新吸收光線，光線不能穿越空間，宇宙是不透明的。當宇宙膨脹並冷卻，等離子體開始形成中性原子，它們不會同樣吸收光線，宇宙變得透明，光線可穿透宇宙，幾乎再沒有吸收。宇宙微波背景就是宇宙誕生38萬年後，宇宙由不透明變為透明時，由熾熱等離子體發出的光。這道光最初屬於可見光及紅外線範圍，但隨着空間膨脹，光波被拉長而變成微波。

What gives off the nearly uniform microwave radiation? According to the Big Bang Theory, the Universe started with an extremely small singularity, and then expanded over the next 13.8 billion years to the cosmos today. When the Universe was very young and hot, it was made of a plasma, which continually emitted and re-absorbed light, preventing the light from traveling freely through space. Essentially, space was opaque. As it expanded and cooled, however, the plasma began to form neutral atoms, which did not absorb light in the same way. The Universe then became transparent, and light propagates essentially freely. The Cosmic Microwave Background (CMB) is the light that was emitted by the hot plasma at the moment the Universe went from opaque to transparent, when the Universe was 380,000 years old. That light was originally at optical and infrared wavelengths, but as space expands, that light is stretched to the microwave region.



此全天圖片顯示了宇宙中最古老的光線，即宇宙微波背景。它顯示出各個方向的溫度只有極小的差異（相差十萬分之一），對應於密度略有不同的區域，正是這些差異後來逐漸演化成為今天的星系和大尺度結構。
This all-sky map shows the oldest light in our Universe, or the Cosmic Microwave Background. It shows tiny temperature fluctuations in different directions (1 part in 100,000) that correspond to regions of slightly different densities which later grew to become the galaxies and large scale structure we see today.

2018邵逸夫生命科學與醫學獎
The Shaw Prize in Life Science And Medicine 2018

2018年度「邵逸夫生命科學與醫學獎」頒予瑪莉－克萊爾·金（Mary-Claire King）以表彰她繪製第一個乳腺癌基因的基因圖。瑪莉–克萊爾·金利用數學模型預測和證明乳腺癌可以由單個基因引起。她繪製的基因圖促成了乳腺癌基因的克隆，因而挽救了許多人的生命。

The Shaw Prize in Life Science and Medicine 2018 is awarded to Mary-Claire King for her mapping of the first breast cancer gene. Using mathematical modeling, King predicted and then demonstrated that breast cancer can be caused by a single gene. She mapped the gene which facilitated its cloning and has saved thousands of lives.

得獎人簡介
Biographical Note of Laureate

瑪莉－克萊爾·金 Mary-Claire King

瑪莉–克萊爾·金（Mary-Claire King）1946年生於美國伊利諾州芝加哥市，現為美國西雅圖華盛頓大學醫學系和基因組科學系美國癌症協會講座教授。1966年於美國明尼蘇達州諾斯菲爾德市卡爾頓學院取得數學學士學位，並於1973年於美國加州大學柏克萊分校獲遺傳學博士學位。她曾於美國加州大學三藩市分校擔任博士後研究員（1974-1976）。於1976年到1995年期間返回加州大學柏克萊分校工作，於公共衛生學院分子與細胞生物學及流行病學系擔任遺傳學助理教授、副教授和教授。自1995年起成為美國西雅圖華盛頓大學醫學系和基因組科學系美國癌症協會講座教授。瑪莉–克萊爾·金是美國國家科學院、美國國家醫學院和美國人文與科學院院士。

Mary-Claire King was born in 1946 in Chicago, Illinois, USA and is currently the American Cancer Society Professor, Departments of Medicine and Genome Sciences at the University of Washington, USA. She obtained her Bachelor's degree in Mathematics from Carleton College, Northfield, Minnesota, USA in 1966 and received her PhD in Genetics from the University of California, Berkeley, USA in 1973. She was a Postdoctoral Fellow at the University of California, San Francisco, USA (1974–1976). From 1976 to 1995, she joined the University of California, Berkeley, where she was successively Assistant Professor, Associate Professor and Professor of Genetics in the Department of Molecular and Cell Biology/Epidemiology in the School of Public Health. Since 1995, she has been an American Cancer Society Professor of Medicine and Genome Sciences at the University of Washington. She is a member of the US National Academy of Sciences, the US National Academy of Medicine and the American Academy of Arts and Sciences.

瑪莉－克萊爾．金的貢獻
Contributions of Mary-Claire King

在美國國家癌症研究中心（NCI）的協助下，金收集了美國1,579名乳腺癌患者及其直系親屬和其他家庭成員罹患乳腺癌的資料。她與其團隊用數學方法分析了這大量數據，並推測家族性乳腺癌是由一個顯性的遺傳因子所致，而這些家庭中大約有4%的成員具有這顯性遺傳因子。她進一步比較了不同年齡組別的數據，並預測了有或沒有這遺傳因子的女性在不同年齡罹患乳腺癌的機率（見下表）。

為了支持她的數學模型並找出這遺傳因子，金對23個家族進行了大型的連鎖分析，這些家庭包含了329名親屬，當中有146個早發而帶擴散性的乳腺癌個案。經過17年的研究，金終於在第17號染色體上鎖定了乳腺癌相關基因1（*BRCA1*），從而開啟了日後克隆該基因的大門。她的突破性發現證明了一些複雜的疾病如乳腺癌可以由單一基因引致，這開創性的發現徹底改變了整個研究領域，並引發了一場克隆該基因的國際競賽。

*BRCA1*基因及其變異的發現使我們能夠透過早期診斷來評估個人患有遺傳性癌症的傾向。金在研究中所利用的數學模型和連鎖分析，也促成了科學家發現其他複雜的疾病，如糖尿病和精神分裂症等的致病基因，並為遺傳流行病學奠定了基礎。最近，金的團隊更開發了BROCA平台，可以同時檢測乳腺癌、卵巢癌、結腸癌、胰腺癌、胃癌和腎癌等的相關基因變異。這些基因檢測有助及早預防複雜疾病的發生及延長人類的壽命。

有或沒有該遺傳因子的女性在不同年齡罹患乳腺癌的機率
The probability of women with or without the genetic factor to have breast cancer

	有遺傳因子的女性 Women with the genetic factor	沒有遺傳因子的女性 Women without the genetic factor
在40歲前罹患乳腺癌的機率 Probability to have breast cancer by age 40	38%	0.4%
在55歲前罹患乳腺癌的機率 Probability to have breast cancer by age 55	66%	2.8%
在一生中罹患乳腺癌的機率 Probability to have breast cancer over a lifetime	82%	8.1%

With the help of the National Cancer Institute (NCI), King collected information from 1,579 breast cancer patients in USA about cases of breast cancer in their immediate and extended family members. She and her colleagues then used a mathematical approach to analyse the large amount of data and postulated that familial clustering of breast cancer could be best explained by the presence of a dominant genetic factor in about 4% of families. She further compared the data from different age groups and predicted the probability of women with or without this genetic factor to have breast cancer in different ages (as shown in the table).

To support her mathematical model and find out this genetic factor, King carried out extensive linkage analysis in 23 extended families consisting of 329 relatives with 146 cases of early-onset invasive breast cancer. After a 17-year research, King finally located the BReast CAncer-related gene 1 (*BRCA1*) in chromosome 17, which allowed subsequent cloning of the gene. Her groundbreaking discovery proved a disease as complex as breast cancer could be caused by a single gene. This dogma-overturning finding revolutionised the entire field and launched an international race to clone the gene.

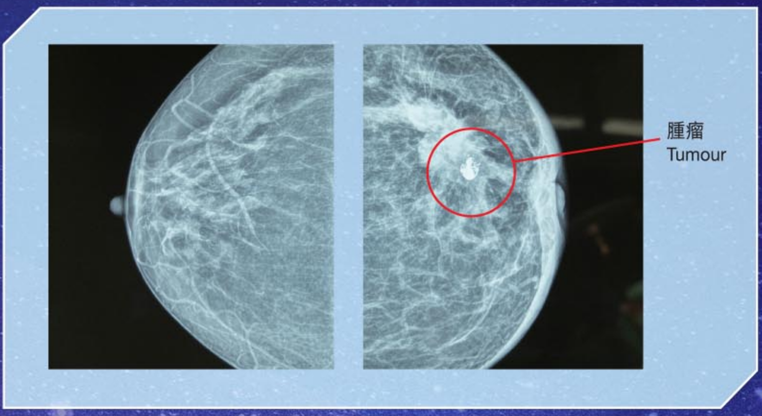
The discovery of *BRCA1* gene and its mutations enables us to carry out early-diagnosis to evaluate if a person has a suspected hereditary cancer predisposition. The introduction of mathematical models and linkage analysis in her researches also provides insights for gene discovery in other complex diseases like diabetes and schizophrenia, and opens up windows in establishment of genetic epidemiology. Recently, her group developed a platform named BROCA, which can simultaneously detect mutations in genes associated with breast, ovarian, colon, pancreatic, gastric and renal cancers, etc. These genetic tests have saved and prolonged the lives of people by allowing them to have prophylactic measures for the diseases.

乳腺癌
Breast Cancer

乳腺癌（又稱乳癌）是女性最常見的癌症。根據世界衛生組織，平均每一百萬名女性便有433名罹患乳腺癌，當中更有三分之一患者會死亡。

乳腺癌是一種複雜的病症，成因多種並錯綜複雜。可能引發乳腺癌腫瘤的風險因素包括從未生育、在30歲以後首次生育、使用某種避孕藥、更年期、曾暴露於游離輻射、高卡路里的飲食習慣、飲酒以及缺乏運動。多樣的因素令醫生難以追查個案的病因及制訂相應的醫治方法。

瑪莉－克萊爾・金的研究生涯大部分時間都專注在癌症流行病學上，她在1974年開展乳腺癌的研究工作，當時的主流觀點認為癌症是由環境因素或病毒感染而偶然發生。金卻留意到某些家族會聚集性地出現乳腺癌個案，她觀察到在女性群中，如果母親或姊妹曾罹患乳腺癌，尤其是兩邊乳房同時發生或者早於更年期發生，她們罹患乳腺癌的風險會較高。這觀察啟發了她的假說，認為這些家族性乳腺癌是由遺傳因子引致。

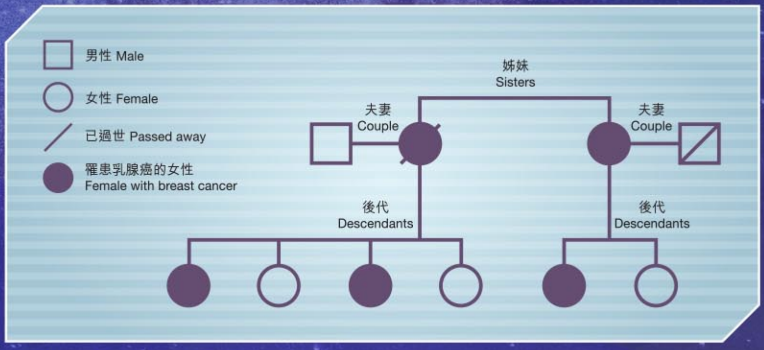


正常的乳房（左）和帶有腫瘤的乳房（右）的X光圖片
The X-ray photographs showing a normal breast (left) and a breast with tumour (right)

Breast cancer is the most common cancer among women. According to the World Health Organisation, it has a high incidence rate of 433 per 1,000,000 women worldwide, in which one-third of the cases cause death.

Breast cancer is a complex disease and its etiology is multifactorial and heterogeneous. Risk factors like nulliparity, first birth after age 30, use of certain contraceptives, menopause, exposure to ionising radiation, high-calorie diets, consumption of alcoholic beverages and lack of exercise, are all implicated in the tumour development, making it hard for physicians to find the prognosis and formulate the corresponding treatment plan.

Mary-Claire King has been spending most of her career addressing the epidemiology of cancer. She began her research in breast cancer in 1974, at a time when most people thought that cancers were sporadic, triggered by environmental factors and viral infections. King, on the other hand, paid particular attention to the clustering pattern of breast cancer cases in some families. She observed that women had a higher risk of breast cancer if they had sisters or mothers affected by the disease, particularly if it was diagnosed prior to menopause and occurred in both breasts. This inspired her hypothesis of the existence of an inherited factor in these family cases.



這家譜展示了家族性聚集的乳腺癌個案
A pedigree showing familial clustering of breast cancer cases

2018邵逸夫 數學科學獎

The Shaw Prize in Mathematical Sciences 2018

2018年度「邵逸夫數學科學獎」頒予路易·卡法雷 (Luis A Caffarelli) 以表彰他在偏微分方程上的突破性工作，包括創立一套正則理論，適用於蒙日–安培方程等非線性方程，及如障礙問題等的自由邊界問題，這些工作影響了該領域整個世代的研究。

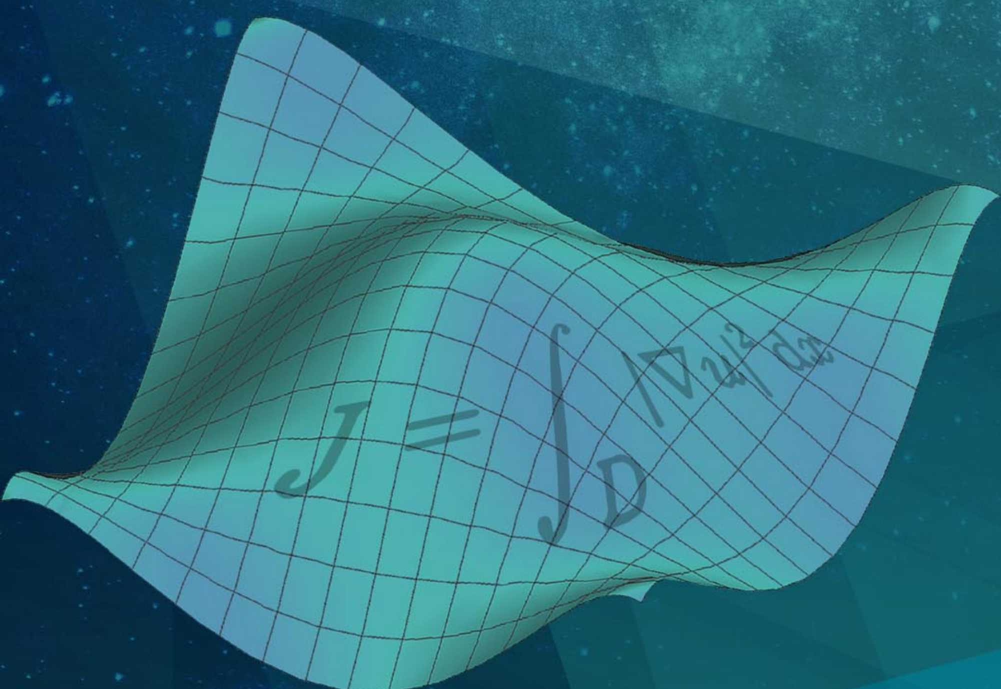
The Shaw Prize in Mathematical Sciences 2018 is awarded to Luis A Caffarelli for his groundbreaking work on partial differential equations, including creating a theory of regularity for nonlinear equations such as the Monge–Ampère equation, and free boundary problems such as the obstacle problem, work that has influenced a whole generation of researchers in the field.

得獎人簡介
Biographical Note of Laureate

路易·卡法雷 Luis A Caffarelli

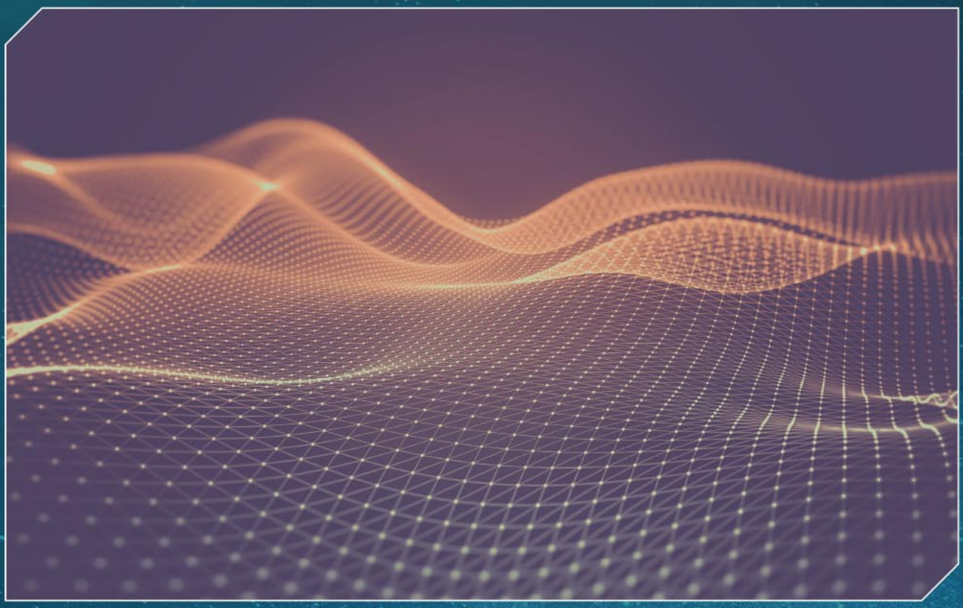
路易·卡法雷 (Luis A Caffarelli) 在1948年於阿根廷布宜諾斯艾利斯出生，現為美國德克薩斯大學奧斯汀分校數學教授。他在1969年於阿根廷布宜諾斯艾利斯大學取得理學碩士學位，並於1972年於該校取得數學博士學位。他畢業後加入美國明尼蘇達大學工作，在1973年至1974年任博士後研究員，1975年至1977年任助理教授，1977年至1979年任副教授，1979年至1983年任教授。他在1980年至1982年於美國紐約大學柯朗數學科學研究所任教授，之後分別於美國芝加哥大學（1983-1986）、美國普林斯頓高等研究院（1986-1996）和美國紐約大學柯朗數學科學研究所（1994-1997）擔任教授。路易·卡法雷是美國國家科學院院士及美國人文與科學院院士。

Luis A Caffarelli was born in 1948 in Buenos Aires, Argentina and is currently a Professor of Mathematics at the University of Texas at Austin, USA. He obtained his Master of Science in 1969 and his PhD in Mathematics in 1972 from the University of Buenos Aires, Argentina. He joined the University of Minnesota, USA, where he was successively Postdoctoral Fellow (1973–1974), Assistant Professor (1975–1977), Associate Professor (1977–1979) and Professor (1979–1983). He was a Professor at the Courant Institute of Mathematical Sciences, New York University, USA (1980–1982), the University of Chicago, USA (1983–1986), the Institute for Advanced Study in Princeton, USA (1986–1996) and the Courant Institute, New York University, USA (1994–1997). He is a member of the US National Academy of Sciences and a Fellow of the American Academy of Arts and Sciences.



卡法雷亦在另一個領域 — 障礙問題，建立了一個全新而又非常有影響力的理論。就像在偏微分方程中所有重要的問題一樣，這個障礙問題在很多情況下都會出現，包括在多孔介質中的流體過濾和金融數學。

一般來講，因為不會常有解決偏微分方程的顯式公式，所以對其特性的分析非常困難，並取決於極其精密的估計。卡法雷是箇中高手，經常提出一些令人覺得不可思議的論證方法。他繼續在這領域的最前線工作，他自己的工作和他的博士門生的研究工作都對該領域產生着極大的影響。他指導的博士生中，很多已經成為非常傑出的數學家。某種程度上，能夠開創一個重要領域的數學家已經不多，但路易・卡法雷卻能接二連三開闢新的研究領域，而這些領域活力十足，歷久常新。



Another area in which Caffarelli has created a new and highly influential theory is obstacle problems. As with all important problems in partial differential equations, this one arises in many contexts, including fluid filtration in porous media, and financial mathematics.

In general, because one does not usually have explicit formulae for solutions to partial differential equations, the analysis of their properties is very hard, and depends on extremely delicate estimates. Caffarelli is a master at this, frequently coming up with arguments that have left other researchers wondering how he could possibly have thought of them. He continues to work at the forefront of the field and has had a huge influence, both through his own work and that of his doctoral students, many of whom have themselves become extremely distinguished mathematicians. In a way that few mathematicians achieve even once, he has repeatedly created important areas almost from scratch that are extremely active to this day.

路易・卡法雷的貢獻
Contributions of Luis A Caffarelli

卡法雷在偏微分方程的領域有十分卓越的貢獻。數學上，只有一些非常簡單的偏微分方程能得到明確的解答，亦即是能夠以精確的方程式表示它們的解，但這情況相當例外。人們只能退而求其次，嘗試證明答案是存在的，並嘗試刻劃答案的一些特性。

其中一個非常重要的例子就是描述粘性流體運動的納維－斯托克斯方程。在這方程中，當給予適當的初始條件下，我們不知道是否必定有永遠保持良好表現的解，抑或奇點會始終出現。形象化地說，如果將一桶水攪動，那麼一星期後這桶水會否爆破？雖然這多數不會發生，但沒有人知道如何證明這點，亦是數學界未能解決的重要問題之一。

雖然我們仍未知道如何解納維－斯托克斯方程，但卻可以找到所謂的「弱解」，它們是滿足方程式的抽象體，但在某程度上並不是我們真正想要的解答。如果可以證明這些解是「正則」的，那麼納維－斯托克斯問題就可以得到解決。卡法雷、科恩和尼倫伯格所獲得的著名結果是迄今以來，最接近這個目標的。它表明除了一個奇點集合之外，正則的弱解是存在的，而且這個奇點集合在數學的精確意義上必須非常小。

Caffarelli has made groundbreaking contributions in the field of partial differential equations. Mathematically speaking, only a few very simple equations can be solved explicitly—that is, one can find an exact formula for their solutions—but this is very much the exception rather than the rule. Instead, one has to be content with being able to show that solutions exist, and with being able to say something about how they behave.

A very important example of this is the Navier–Stokes equation, which describes the motion of a viscous fluid. It is not known whether, given appropriate initial conditions, there must be a solution to the Navier–Stokes equation that remains well-behaved forever, or whether singularities will necessarily develop. To put it more graphically, if you stir a bucket of water, is there a danger that a week later it will blow up? Probably not, but nobody knows how to prove this, and it is one of the major unsolved problems of mathematics.

Although it is not known how to solve the Navier–Stokes equations, one can find so-called “weak solutions”, which are abstract objects that solve the equations, but not in quite the sense one wants. If one could show that these solutions were “regular”, then the Navier–Stokes problem would be solved. A famous result of Caffarelli, Kohn and Nirenberg is the closest anybody has come to that: it shows that weak solutions exist that are regular except on a set of singularities that has to be very small, in a precise mathematical sense.