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ASTRONOMY AND SPACE ON THE BIG SCREEN

HOW ACCURATELY HAS CINEMA PORTRAYED SPACE TRAVEL AND OTHER ASTROPHYSICAL CONCEPTS?

Miguel Alcubierre

Since its origins, cinema has been fascinated with the subject of scientific developments. In particular, astronomy and astrophysics have played an important role in science fiction stories about space travel and exploration. Though the science has not always been accurately represented, in the last decades there has been more and more interest from the cinema industry in approaching scientists to make sure that the stories and concepts shown in films are closer to our true understanding of the universe. In this article, I will explore how cinema has portrayed astrophysical concepts throughout the decades, and how sometimes cinema has even inspired the direction of scientific research.

Keywords: astronomy, cinema and science fiction, space travel, asteroids, black holes.

Ever since the early days of cinema, astronomy and space have been subjects that have fascinated audiences. The first film that deals with astronomy was *The astronomer's dream,* directed by George Méliès in 1898. This film, which was originally called *La Lune à un mètre* ("The Moon at one meter"), is however more a dreamlike sequence than a proper science fiction film. A few years later, in 1902, Méliès also directed what could be considered the first ever science fiction film, *A trip to the moon*. It is not surprising that cinema, with its capacity to show imaginary worlds, would touch on the realm of science fiction and fantasy, allowing us to see what previously we could only imagine.

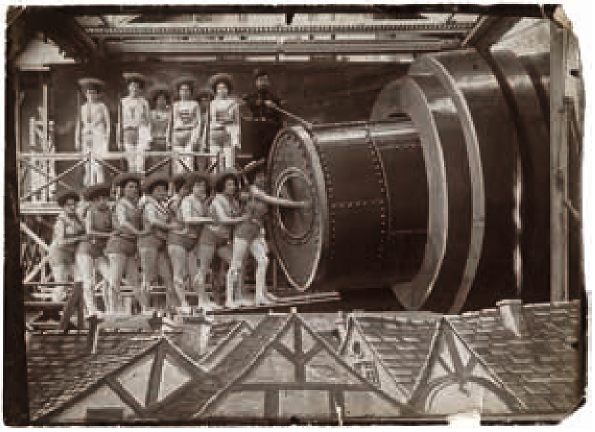
Over the last century there has been a mutual relation between cinema and science, and cinema and astronomy in particular, where movies have been inspired by scientific developments, and in turn young minds have become enamoured with astronomy through cinema. This relationship has not always been true to hard scientific facts, since the limitations that nature imposes often get in the way of a good story. Because of this, there has been a tense relationship between real science and movie science, with scientists complaining frequently, and often bitterly, about the inaccuracies of science fiction movies.

«OVER THE LAST CENTURY THERE HAS BEEN A MUTUAL RELATION BETWEEN CINEMA AND SCIENCE, WHERE MOVIES HAVE BEEN INSPIRED BY SCIENTIFIC DEVELOPMENTS»

Cinema has explored many aspects of science, from time travel to genetic engineering and virtual reality. Here I will concentrate mainly on astronomy and astrophysics and focus on some simple questions. Has the science been correctly portrayed? When the science is not yet settled, has cinema captured the speculations of scientists adequately? Has cinema inspired the direction of new scientific research?

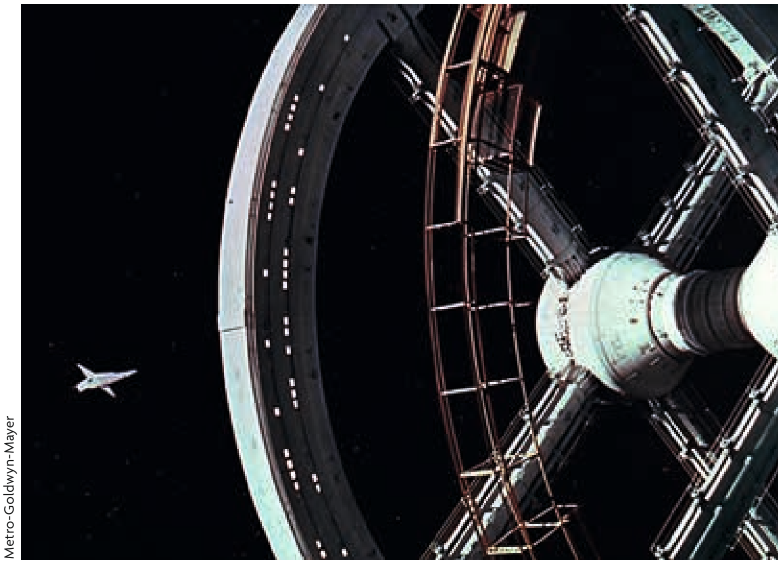
The subject is of course vast, so I will consider some general themes that seem to me to be particularly representative: space travel and astrophysical phenomena. I will leave aside the subject of extraterrestrial life and civilizations which, though certainly related, would require a review of its own.

There are some previous studies about the relationship between science fiction films and science itself. In particular, one can mention the recent book *Hollywood science* by Sidney Perkowitz (2007),



La Cinémathèque française. Photo: Stéphane Dabrowski

In *A trip to the moon* (1902), considered the first ever science fiction film, George Méliès imagined a trip to the satellite inside a capsule fired by a cannon. In the picture, people loading the cannon in the movie.



Metro-Goldwyn-Mayer

There are several scientifically accurate cinema representations of space travel. The classic reference for scientifically accurate space travel is clearly the film *2001: A space odyssey* (1968), but there are other films that have represented space missions accurately, such as *Apollo 13* or *Gravity*. In the picture, a scene from Stanley Kubrick's movie representing a space station that spins to create artificial gravity.

which however does not deal much with the subject of astrophysics, and several other books that deal with science in both cinema and television like *The physics of Star Trek* (Krauss, 1995) and *De King Kong a Einstein: La física en la ciencia ficción* ("From King Kong to Einstein: Physics in science fiction", Moreno Lupiáñez & José Pont, 1999).

REALISTIC SPACE TRAVEL

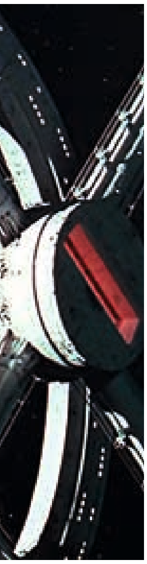
One of the main themes in science fiction has always been that of space travel. As I mentioned above, even in the early days of cinema we already had a movie that speculated with traveling to the Moon, George Méliès's *A trip to the Moon* from 1902. In that movie, there is really not much science and very few special effects, the arrival of the capsule to the Moon is more comical that anything else. But the method for reaching the Moon, inside a capsule fired by a cannon, had been proposed by Jules Verne in his 1865 novel *From the Earth to the Moon*. From today's point of view, being shot from a cannon seems absurd since the tremendous accelerations would kill the travellers instantly. But the idea that the Moon is a world one could imagine physically travelling to was certainly something audiences where not familiar with at that time. Jules Verne's book, and perhaps to some extent Méliès's movie, were an inspiration for the true voyages to the Moon of the 1960s.

In real life the trip to the Moon was far more complex that the movie version, and at the same time the outcome, though transcendental and wondrous, was somewhat boring: no Selenites were waiting to capture the astronauts, who just planted a flag and gathered rock samples. Movies about space travel became more sophisticated over the decades, reflecting a variety of themes in the science fiction literature. They can be mostly separated into two categories: those depicting realistic space travel mostly within our own solar system, and those dealing with speculative ideas for faster than light interstellar travel.

«THERE HAS BEEN A TENSE RELATIONSHIP BETWEEN REAL SCIENCE AND MOVIE SCIENCE, WITH SCIENTISTS COMPLAINING FREQUENTLY ABOUT THE INACCURACIES OF SCIENCE FICTION MOVIES»

From the late 1930s all the way to the early 1960s, during the so-called «golden age» of science fiction, space travel within our own solar system was typically shown in the way of increasingly sophisticated rocket ships. In 1933 the comic strip character Buck Rogers was brought for the first time to the big screen in the form of a ten-minutes short film called *Buck Rogers in the 25th century: An interplanetary battle with the tiger men of Mars*, directed by Harlan Tarbell and shown in the Chicago World Fair. Later, Universal Pictures produced a series of twelve Buck Rogers films in 1939, directed by Ford Beebe and Saul A. Goodkind. Buck Rogers's rocket ships, though not

20th Century Fox



particularly realistic, nevertheless depicted what the public expected space travel to look like at that time. Other realistic space travel examples can be found in *Rocketship X-M* (1950), *Project Moonbase* (1950), and *Destination Moon* (1950).

The classic reference for scientifically accurate space travel is clearly the film *2001: A space odyssey* (1968). The film, directed by Stanley Kubrick, and with a script written by Kubrick himself and science fiction legend Arthur C. Clarke (who later turned it into a novel), imagines a not too distant future with advanced space stations, Moon bases, and a manned trip to the moons of Jupiter. The fact that all this is already supposed to have happened in the year 2001 should not distract us, it might as well have been 2101, but the science is beautifully taken into account. It is the prime example of «hard» (i.e., scientifically accurate) science fiction in cinema. The space ship that leaves Earth is a prediction of what the space shuttle would actually look like. The space station in Earth's orbit spins to generate «artificial gravity» through centrifugal force. The trip to Jupiter takes many months on board a nuclear-powered space ship, which again has a spinning section to generate gravity. The movie was filmed one year before the Apollo mission to the Moon, and shows how real space travel might actually look like in the not too distant future. The film deals also with other themes such as artificial intelligence and extraterrestrial life, but its attention to scientific detail is quite remarkable. At the time this film was made very little was known of the Jupiter system other than the existence of its four largest Galilean moons (Io, Europa, Ganymede, and Callisto). But all this changed little more than ten years later when the Voyager 1 probe flew by Jupiter and its moons in 1979. Arthur C. Clarke then used this new information for a sequel to the novel, which was also adapted to cinema in the movie *2010: The year we make contact* (1984), directed by Peter Hyams, and where he imagined that life had evolved beneath the icy surface of Jupiter's moon Europa, a scientific speculation that continues to our day.

«MOVIES ABOUT SPACE TRAVEL BECAME MORE SOPHISTICATED OVER THE DECADES, REFLECTING A VARIETY OF THEMES IN THE SCIENCE FICTION LITERATURE»

The Martian describes a mission to Mars, where, due to an accident, an astronaut must survive alon on the red planet's surface for months. In the picture, a still from the film starring Matt Damon.

Realistic representations of space travel in cinema have continued. The most realistic to date is in fact a true story, the film *Apollo 13* (1995), directed by Ron Howard. This film, which was based on the book *Lost Moon* by Jim Lovell (one of the astronauts in the mission) and Jeffrey Kluger (Lovell & Kluger, 1994), shows in great detail the events related to the accident of the Apollo 13 mission in 1970. It is amazing that space travel has reached the point where cinema can represent a real historical mission and not just a fictional one.

The recent film *Gravity* (2013), by Alfonso Cuarón, imagines in great detail how an accident in low Earth orbit could look like, and shines a light on the very real problem that the proliferation of space junk represents for space missions today. Even more recently, the film *The Martian* (2015), by Ridley Scott, based on the novel of the same name by Andy Weir (2014), describes how a mission to Mars could look like in thirty years' time, and explores how a stranded astronaut could survive on the Martian surface for months. Cinema has also portrayed a topic that today has become a common conspiracy theory. The film *Capricorn One* (1977), by Peter Hyams, describes how a planned manned mission to Mars that has suffered serious financial setbacks is then faked in a TV studio. Today some people believe that the Moon landing was indeed faked in such a way.

Cinema has also considered interstellar voyages at close to the speed of light. According to Einstein's theory of special relativity, if we travel close to the speed of light time slows down when compared to the flow of time back on Earth. This phenomenon, known as «time dilation», has been confirmed to high accuracy in particle accelerators. To observe time dilation on a space ship one would need to make a round trip to a nearby star at speeds very close to the speed of light. After such a trip, the astronauts would have experienced just a few years, while on Earth decades or even centuries could have elapsed. Such a scenario was depicted in the film *Planet of the apes* (1968), directed by Franklin J. Schaffner, in which after a long space trip the main character finds himself on a planet where apes are the dominant species, only to discover later that he is in fact back on Earth many centuries in the future.

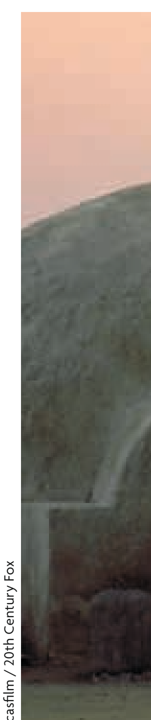
«AS FAR AS WE UNDERSTAND TODAY, FASTER-THAN-LIGHT TRAVEL REMAINS IMPOSSIBLE. THIS IS NOT BECAUSE OF SOME TECHNOLOGICAL HURDLE, BUT BECAUSE OF THE WAY OUR UNIVERSE IS BUILT»

Warner Bros Pictures

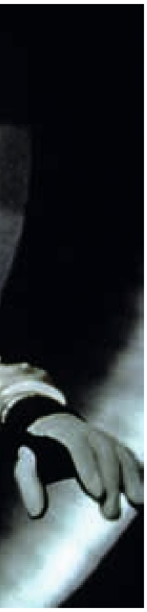
In *Contact*, the film based on Carl Sagan's novel, an extraterrestrial civilization sends humanity the design of a machine to generate a wormhole. The scientist Eleanor Arroway (played by Jodie Foster) is in charge of testing the machine.

FASTER-THAN-LIGHT SPACE TRAVEL

Regarding faster-than-light space travel we need to start from the following fact: as far as we understand today, faster-than-light travel remains impossible. This is not because of some technological hurdle, but because of the way our universe is built. According to special relativity, nothing can travel faster than light because this would violate causality and would allow one to send information back in time. Still, some loopholes have been proposed and there are several speculative ideas about how one could reach distant stars faster than light without breaking relativity. For this, one needs to use Einstein's theory of general relativity, according to which space and time can be distorted or «curved». This curvature of space-time is produced by large concentrations of mass and manifests itself as the ordinary force of gravity. But extreme distortions of space-time can give rise to more exotic phenomena such as black holes (see below). It turns out that one can imagine large distortions of space-time that can allow faster-than-light travel or, more correctly, faster than light



Lucasfilm / 20th Century Fox



would have travelled in flat space: light will still beat us if it travels through the same distorted space.

The first such idea can be traced back to Einstein himself and his collaborator Nathan Rosen, who in 1935 discovered that the mathematics of general relativity allowed for the existence of «tunnels» through space (Einstein & Rosen, 1935). This so-called «Einstein-Rosen bridges» connect distant regions of space and they have been used extensively in science fiction, where they are usually called «portals» or «wormholes». One should mention the fact that even though wormholes are in principle allowed by the laws of physics, we have no idea how one could be created. They also require a form of antigravity to keep them open, which probably does not exist in nature. An example of the use of wormholes for space travel in cinema is the film *Stargate* (1994), by Roland Emmerich, in which wormholes are represented by gates through which one can just step to reach a distant world. The film and subsequent TV series are notable because they involve interstellar space travel without spaceships. Wormholes also make an appearance in the film *Contact* (1997), directed by Robert Zemeckis, based on the novel of the same name by Carl Sagan (1985). In the film, an advanced extraterrestrial civilization contacts humanity and sends us the design for a machine that creates a wormhole. One should mention the fact that for his novel Sagan asked for help from Kip Thorne, a renowned theoretical physicist, who suggested the use of wormholes instead of black holes for the novel, and later did important scientific research in that area (Morris & Thorne, 1988).

«THE EXISTENCE OF HABITABLE EXTRA SOLAR PLANETS, THOUGHT HUGELY IMPORTANT FORM A SCIENTIFIC POINT OF VIEW, IS NOTHING NEW IN SCIENCE FICTION CINEMA»

Another idea for faster-than-light travel was introduced by myself in 1994, and is generally called a «warp drive» (Alcubierre, 1994). This idea is an example of TV and cinema influencing science, instead of the other way around. The name «warp drive» has been around in science fiction since the late 1960s with the *Star Trek* TV series (1966-1969), created by Gene Roddenberry, and implies that one achieves faster-than-light travel by somehow «warping» space. Precisely what this

The existence of habitable extra solar planets, is nothing new in science fiction cinema. Some are unusual, like the planet Tatooine from the *Star Wars* saga. This planet orbits a binary star system. In *Return of the Jedi*, there are inhabited satellites, such as the Endor moon.

warping does is of course never explained. In 1994, I came up with the idea of violently expanding a small region of space behind a spaceship, and contracting a region in front of it, with the spaceship sitting in a bubble of flat space in the middle. This warp bubble would push the spaceship, and since there is no limit to the speed at which space itself can expand it could in principle move faster than light. Just as with wormholes, however, a warp bubble would require some sort of antigravity, and today we have no idea how to create one.

Paramount Pictures

ASTROPHYSICAL PHENOMENA

Let us now move away from space travel and consider how different astrophysical phenomena have been depicted in cinema, from asteroids and moons, to planets, stars and even black holes.

Starting from the small scales, asteroids have in the last couple of decades started to appear in movies and science fiction novels, so much so that the science fiction author Larry Niven classifies these stories as a subgenre in itself, which he calls Big-Rock-Hits-Earth novels. This has been inspired by the suggestion by – almost universally accepted today – that the impact of a large asteroid caused the mass extinction that killed off the dinosaurs at end of the Cretaceous period 65 million years ago (Alvarez, Alvarez, Asaro, & Michel, 1980). The suggestion was initially received with great scepticism, but became more and more likely, until it became almost universally accepted when a huge 180 km diameter crater with the correct age was discovered in the Yucatan peninsula, centred near the town of Chicxulub.

Such a catastrophe quite literally falling from the sky has of course ignited the imagination of scientists and science fiction writers alike. Could it happen now and wipe out human civilization? Could we prevent it if we had prior warning? This was taken to the cinema in 1998 with two almost simultaneous movies, *Deep impact*, directed by Mimi Leder, and *Armageddon*, by Michael Bay. The contrasts between both films couldn't be greater, with *Deep impact* depicting a realistic scenario for both the discovery of the asteroid and the possibility of deflecting it, and *Armageddon* throwing science out the window and focusing on a group of space cowboys saving the planet. In both films, however, the asteroid is ultimately destroyed using nuclear weapons, which we now know is not a good idea, as the millions of resulting fragments would still hit Earth with results just as catastrophic. To be fair, a similar story was already depicted in the film *When worlds collide* of 1951, by Rudolph Mate, in which instead of an asteroid a rogue planet is in a collision course (and in fact does collide) with Earth.

«CINEMA HAS GONE BEYOND CONSIDERING A MULTITUDE OF PLANETS AND MOONS, AND HAS ALSO REPRESENTED MORE EXOTIC ASTROPHYSICAL PHENOMENA. TOP OF THE LIST ARE OF COURSE BLACK HOLES»

Let us now consider planets. Direct scientific evidence for the existence of extra solar planets had to wait until 1988, when Canadian astronomers discovered a planet in orbit around the star Gamma Cephei, also known as Errai (Campbell, Walker, & Yang, 1988). To date, over 3,000 extra solar planets have been found, most of them by the Kepler satellite that measures the drop in luminosity of a star as a planet crosses in front of it. Potentially

Walt Disney Studios

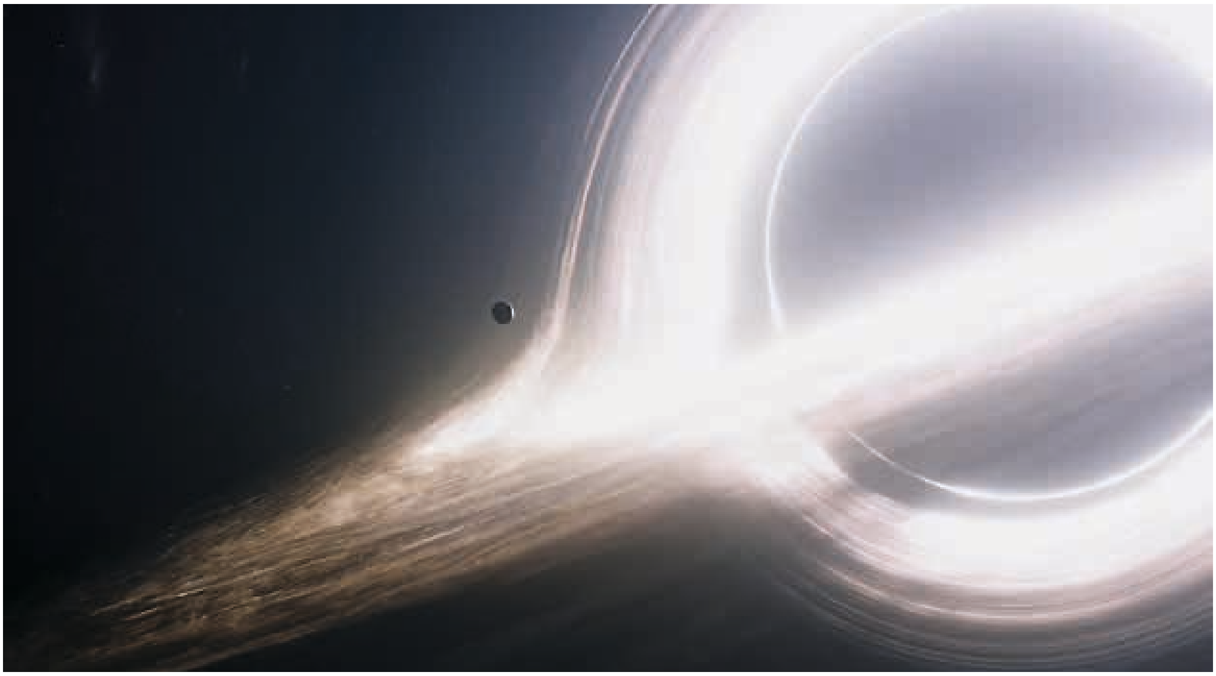
In 1998, two films described the imminent impact of an asteroid with the Earth: *Deep impact* and *Armageddon.* While the first (above) showed a realistic scenario, the second one threw science out the window and focused on the story of a group of space cowboys (below) who saved the Earth.

habitable planets of similar size to Earth orbiting at an appropriate distance from their star for liquid water to exist have proven more difficult to find. Still, about ten such planets have been found so far, with masses ranging from 2 to 5 times the mass of the Earth.

The existence of habitable extra solar planets, is nothing new in science fiction cinema, going back at least to the film *Forbidden planet* (1956), directed by Fred M. Wilcox. Perhaps more interesting is the existence of unusual planets, such as the planet Tatooine from *Star Wars* (1977), by George Lucas, that orbits a binary star system. Only about 5 such circumbinary planets have been discovered so far, the most recent one being Kepler-1647, which is a Jupiter sized planet about 3,700 light years from Earth that orbits in the habitable zone of a binary star system (Kostov et al., 2016). The planet is a gas giant and thus not very similar to Earth, but one can imagine it having large moons that would be friendly to life. Indeed, movies have also imagined the possibility of life in moons that orbit giant planets. One such case is the forest moon of Endor, from *Return of the Jedi* (1983), directed by Richard Marquand. A more recent example from the film *Avatar* (2009), by James Cameron, is the moon Pandora, which orbits the gas giant planet Polyphemus in the Alpha Centauri star system.

«CINEMA HAS HELPED US BRING SUCH EXOTIC PHENOMENA OUT OF THE OBSERVATORIES. THROUGH CINEMA THE GENERAL PUBLIC CAN LEARN ABOUT THE UNIVERSE IN A WAY THAT HAS A STRONGER IMPACT THAN OTHER MEDIA»

Other interesting planets depicted in cinema are those with orbits around multiple star systems. In the film *Pitch black* (2000), by David Twohy, the main characters are stranded on a desert moon orbiting a gas giant planet in a triple star system, such that there is daylight for very long periods of time, except when the giant planet happens to eclipse the main pair of stars, which is of course when interesting things happen in the form of nasty night adapted creatures. The film reminds us of the short story *Nightfall* by Isaac Asimov, where a civilization flourishes on a planet with six suns, where night is unknown except during an eclipse every 2,000 years. The ensuing total darkness is enough to cause the cyclical collapse of the planet's civilization.



Warner Bros pictures, 2014

But cinema has gone beyond, and has also represented more exotic astrophysical phenomena. Top of the list are of course black holes, predicted by Einstein's general theory of relativity as the result of the gravitational collapse of large concentrations of mass, and as such are the end stage in the life cycle of very massive stars. Their name comes from the fact that for a black hole gravity is so strong that not even light can escape, and if light can't escape nothing else can (black holes can in fact evaporate due to quantum effects, as was discovered by Stephen Hawking in 1974, but this process in only important for microscopic black holes, and is negligible for astrophysical ones). The surface of no return, beyond which it is impossible to come back out again, is known as the «event horizon». Once something crosses the horizon it is destined to fall into the centre of the black hole where the gravitational force becomes infinite, the so-called «singularity». Black holes are real astrophysical phenomena, and we now have very strong evidence for their existence. The strong gravity close to a black hole also slows down the flow of time. On Earth, clocks on the surface lose one second every thirty years with respect to clocks in outer space. But close to a black hole the effect is huge.

The best depiction of a black hole in cinema so far has been in the film *Interstellar* (2014), by Christopher Nolan, where the main characters travel to a system of planets in orbit around a supermassive black hole called Gargantua. The effects of the extreme time dilation close to the black hole are

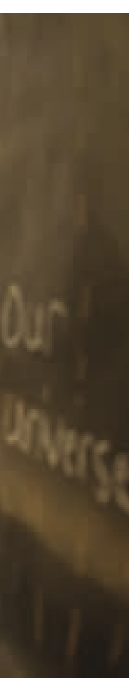
The best depiction of a black hole in cinema so far has been in the film *Interstellar* (2014). In the image of Gargantua (above) we observe a surrounding gas disk that is heated due to friction to the point of becoming a light and heat source, as the Sun in our own system. The image of the black hole and the disk gas was generated by a supercomputer using the real mathematical solution to the equations of the theory of general relativity in order to trace the correct path of light rays around the curved geometry of the black hole. The film had the North American physicist Kip Thorne as scientific advisor. In the picture below, he is seen working during the film shot, writing on the blackboard of the main character.

Warner Bros pictures, 2014/Melinda Sue Gordon shown when the astronauts visit a planet (Miller Planet) where every hour at the surface corresponds to many years outside. The film is also notable for the fact that Kip Thorne was their scientific advisor, and even wrote a book about the science of the film (Thorne, 2014). Of course, once the protagonist falls into the black hole the film enters the realm of pure speculation, with a multi-dimensional space that even allows him to send information back in time. In reality the interior of a black hole is not nearly that exotic, with the exception of the central singularity where our theories break down and we enter the realm of «quantum gravity», a theory that we still have not fully developed.

Interstellar also depicts a wormhole as the means the main characters use for traveling from our solar system to Gargantua's system. Even if the wormhole is just as speculative as in any other film, its visual representation is again an accurate light ray tracing of the correct wormhole geometry. In fact, black holes and wormholes are related to each other. Einstein and Rosen's original discovery was of a wormhole inside a black hole solution. This explains why black holes in cinema are often seen as gates to different regions of space, such as in Disney's film *The black hole* (1979), by Gary Nelson.

«SCIENCE FICTION LITERATURE AND CINEMA HAVE AN IMPORTANT ROLE TO PLAY IN SCIENCE COMMUNICATION»

CONCLUSIONS



We live in a relatively quiet corner of the galaxy, where we have had time to evolve and develop untouched by the outside universe. But as our science has advanced we have learned that the universe is far more violent and complex than we imagined. Modern astronomy has allowed us to discover planets outside our solar system, exploding stars, black holes, and even gravitational waves. As we slowly become an interplanetary and even an interstellar species, we will encounter astronomical phenomena far more exotic than anything on our own solar system.

Fiction, and particularly cinema, has helped us bring such exotic phenomena out of the observatories. Through cinema the general public can learn about the universe in a way that has a stronger impact than other media. Though the science has often not been represented accurately, there has recently been an increasing interest to seek the advise of scientific experts in order to be more faithful to current scientific knowledge. Science fiction cinema and literature have also inspired young people to pursue scientific careers, and in a few occasions, they have even inspired scientists to look beyond what we already know.

The modern world clearly depends more and more on science and technology. If we want an educated society that understands the world we live in, scientists have the responsibility to explain in simple ways what we have learned and how we have learned it. Science communication therefore becomes essential, but there are many different ways to communicate science. I believe science fiction literature and cinema have an important role to play in this, and as scientists we should make an effort to make sure that in those cases when the science is understood it is represented as accurately as possible. And when a story requires speculative science, that at least it does not ignore everything we have already learned.

REFERENCES

Alcubierre, M. (1994). The warp drive: Hyperfast travel within general relativity. *Classical Quantum Gravity*, *11*, L73–L77. doi: 10.1088/0264-9381/11/5/001

Alvarez, L. W., Alvarez W., Asaro, S., & Michel, H. V. (1980). Extraterrestrial cause for the Cretaceous-Tertiary extinction. *Science*, *208*, 1095–1108. doi: 10.1126/science.208.4448.1095

Campbell, B., Walker, G. A. H., & Yang, S. (1988). A search for sub-stellar companions to Solar-type stars. *Astronomical Journal*, *331*, 902–921. doi: 10.1086/166608

Einstein, A., & Rosen, N. (1935). The particle problem in the general theory of relativity. *Physical Review*, *48*, 73–77. doi: 10.1103/PhysRev.48.73

Hawking, S. W. (1974). Black hole explosions. *Nature*, *248*, 30–31. doi: 10.1038/248030a0

Kostov, V. B., Orosz, J. A., Welsh, W. F., Doyle, L. R., Fabrycky, D. C., Haghighipour, N., … Borucki, W. J. (2016). Kepler-1647b: The largest and longest-period Kepler transiting circumbinary planet. *The Astrophysical Journal*, *827*(86). doi: 10.3847/0004-637X/827/1/86

Krauss, L. M. (1995). *The physics of Star Trek*. New York: Basic Books.

Lovell, J., & Kluger, J. (1994). *Lost Moon: The perilous voyage of Apollo 13*. Boston: Houghton Mifflin.

Moreno Lupiáñez, M., & José Pont, J. (1999). *De King Kong a Einstein: La física en la ciencia ficción*. Barcelona: Ediciones UPC.

Morris, M. S., & Thorne, K. S. (1988). Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity. *American Journal of Physics*, *56*(5), 395–412. doi: 10.1119/1.15620

Perkowitz, S. (2007). *Hollywood science: Movies, science and the end of the world*. New York: Columbia University Press.

Sagan, C. (1985). *Contact*. New York: Simon and Schuster.

Thorne, K. S. (2014). *The science of Interstellar*. New York: W. W. Norton & Company.

Weir, A. (2014). *The Martian*. New York: Broadway Books.

Miguel Alcubierre. PhD in Physics. Since 2012, he is the director of the Nuclear Science Institute of the National Autonomous University of Mexico (UNAM), where he conducts his research on numerical relativity. Within this area, he has focused on the simulation of gravitational waves sources, particularly on the collision of two black holes. He is a member of the National System of Researchers and the Mexican Academy of Sciences. In 2009, he received the Medal for Merits in Science of the Legislative Assembly of the Federal District.