

## From Artilleryman to Head of State: how Astronomy inspired François Arago

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**Abstract.** François Arago studied maths at the Ecole Polytechnique in Paris in order to be an artillery officer. His adventurous experiences with astronomy during what we would call a gap year in 1806-08 during the Napoleonic Wars inspired him into a scientific career in which he became the scientific director of the Paris Observatory and the Secretary of the Academie des Sciences. He introduced Foucault's pendulum, leading to crowds of Parisians gawping at the rotation of the Earth and arranged for the French nation to buy Daguerre's invention. He was briefly Head of State in 1848, a level attained by few other astronomers. I will outline his adventures and career as an exemplar of the inspiration of astronomy.

Although his name sounds Spanish, François Arago (1786-1853) was a French astronomer.<sup>1</sup> He was born in the region of Roussillon, in Estragel, in the Pyrenees, on the Spanish border. His father was a customs official. His native language was Catalan, hence his name. He discovered as a

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<sup>1</sup> See Paul Murdin, *Full Meridian of Glory* (New York: Copernicus Publishers, 2008); and Paul Murdin, *Pursuit of Gazelles* (Netherlands: Conserve Press, 2011), a fictional biography or historical novel of Arago's adventures as a young man. The most comprehensive recent biography of Arago is James Lequeux, *François Arago: un savant généreux* (Paris: EDP Sciences, 2009). Arago's account of his adventures in the Mediterranean is the major part of his book *Histoire de ma Jeunesse*. Both the French text and the text of an English translation by W. H. Smyth and others of this, the first chapter, *History of my Youth*, are in a collection called *Biographies of Distinguished Men*, and are available at several locations, including <http://www.gutenberg.org/ebooks/16775> <http://gallica.bnf.fr/ark:/12148/bpt6k92707n.image.f41> and <http://etext.lib.virginia.edu/etcbin/toccer-new2?id=AraBiog.xml&images=images/modeng&data=/texts/english/modeng/parsed&tag=public&part=1&division=div1> or <http://m.umnet.com/Download/.../Biographies-of-Distinguished-Scientific-Men.pdf> (accessed 1 November 2010).

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schoolboy that he had an interest in and a facility in mathematics. He met the French astronomer, Pierre Méchain, who visited Arago's father during his survey of the Paris Meridian, but Méchain discouraged Arago's interest in the pursuit of an academic career in mathematics or astronomy, advising instead that Arago should be more practical in his ambition. As a boy, Arago was attracted by the bright uniforms of Spanish and French soldiers as they passed through his home town, and when he was told by an artillery officer of the possibility that he could become a soldier through an education by merit and scholarships, he fell with enthusiasm upon the idea.

Determined therefore to become an artilleryman, Arago attended college in Perpignan and then successfully competed to attend the *École Polytechnique* in Paris to study maths. The course was not to his liking. He found the students boorish, the content of the course facile, and the professors lazy and incompetent. When in 1806, at the age of 20, he was offered a respite from the course, he accepted with enthusiasm—always, however, intending to return to his studies and career intentions. It was thus that he took up a temporary position in what we would now call a 'gap year' as an administrator and scientific assistant at the Paris Observatory.

At the Paris Observatory, Arago worked with Jean-Baptiste Biot on routine measurements of the properties of gases, like the refractive index (measured in conjunction with the problem of the effect of refraction on star positions). This relatively routine work proved Arago's meticulous ability to make scientific measurements but it could not have been very exciting, and evidently Arago was looking for an opportunity for adventure.

The suggestion came up that he should participate in an expedition to extend the geodesic survey of France into Catalonia and the Balearic Islands, completing Méchain's work, which had been left incomplete when Méchain died of a fever caught in coastal swamplands. The meridian through Paris had been measured with progressive accuracy, starting in the seventeenth century under the direction of Jean Picard and Gian Domenico Cassini, and subsequently by Cassini's descendants. At first the measurements were intended to establish the meridian as a spine for the cartographic triangulation of France. The survey developed into a means to determine the shape of the Earth and to see whether Isaac Newton's calculation was true that, due to its rotation, it was an oblate spheroid. The survey was also a key element in the development of a standard system of weights and measures intended by

the post-revolutionary government to make it easier to trade from one region of France to another, but which went on to become the basis for the global scientific 'metric system' of measurement. The standard of length, the metre, was to be defined fundamentally as one ten millionth of the distance from the pole to the equator of the Earth.

The survey began with the establishment of a baseline, originally laid out on the plain south of Paris, where Orly Airport now is—in fact the track, which the surveyors cut in order to lay standard measuring sticks on the ground over a distance of many kilometres, became a straight road and is now a six-lane highway, Route National 7, which takes you from the centre of Paris to the airport terminals, a highly visible influence that astronomy has had on France. From the ends of the baseline, the surveyors triangulated to churches, mountaintops, castles, and onwards, straddling the meridian from north to south across France, from Dunkerque to Perpignan, using techniques invented by Willebrord Snell (1617). In addition, the surveyors measured the latitude and longitude of selected places by making astronomical measurements from temporary observatories erected for the purpose. The survey thus linked the relative linear positions of places one to another to their angular positions expressed on the surface of the terrestrial globe.

The survey petered out after the French border, although Méchain had twice attempted to extend it into Spain. Arago travelled in 1806 to eastern Spain, with Biot as his supervisor, to extend the survey southwards through Catalonia—no doubt his language skills played a part in establishing his suitability for the job. It was, however, not a good time to go to northeast Spain. Spain had been annexed into the Napoleonic Empire and was descending into revolt and anarchy. The mountains were bandit country and towns were lawless. Arago was given an escort of armed police to help him access suitable mountaintops to sight from one to another. He had to evade bandit gangs more than once, on one occasion meeting the local bandit chief face to face.

Bandits were not his only adventure in the field. At one of his remote bases, situated near a monastery, monks who had conversed with him against the rules of silence that they espoused, criticising their superiors, became concerned as to whether Arago might betray their indiscretions, and Arago became convinced that they had poisoned communion wine that he was being offered. He escaped this possible assassination attempt. On another occasion, while waiting for an instrument to be repaired in Paris, he found a young lady with whom to dally who had a jealous Spanish fiancé. The fiancé lay in wait with an

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accomplice to attack Arago as he left her house, and Arago escaped only by killing one of them by running him over with his carriage.

By 1808 Arago was in Majorca, finishing the series of observations at the southernmost tip of the survey. Spain was by this time in full rebellion against Napoleonic rule (the famous painting by Goya of French soldiers shooting patriots on the Third of May 1808 is of this time). Britain, of course, was fomenting the uprising to occupy Napoleon's western flank in what is now known as the Peninsular War. Britain was also, through its naval superiority, dominating the Mediterranean Sea and Arago had been equipped with a passport from the Royal Society of London, attesting to the scientific nature of his activities, and asking that he be allowed passage by sea through waters controlled by the Royal Navy.

In Majorca, the citizens heard that French sailors were coming to conscript them into Napoleon's army and sought out French officials for retribution. Suspicion fell on the French astronomer on the Majorcan mountaintops. He was seen to have been busy with telescopes and lighting fires. This was so that his mountaintop could be seen at night from mountaintops on the mainland, but the populace interpreted his activity as somehow communicating with the French navy lying over the horizon. The mob suspected that Arago was a French spy and sought him out for vengeance. Arago disguised himself in local clothes and, on his way down the mountain, he was able to converse as a local native with the mob coming up, since the Majorcan language is a dialect of Catalan. Evading the lynch mob, Arago gave himself up to local authorities in the port and was imprisoned for his own safety. His story as a spy leaked out, exaggerated, and he had the rare experience of reading in a newspaper about his own execution; he took some comfort that the report said that he had met his fate heroically.

Eventually he was freed and sailed home towards Marseilles in an Algerian ship. However, he was captured by pirates. His ship was detained off Barcelona by Spanish corsairs and the ship, Arago, the other passengers and the crew were held hostage in La Rosa. The ship was eventually freed after the Regent of Algiers paid a ransom, and Arago again set sail for Marseilles. The ship was damaged in a storm off Sardinia and blown by the mistral across the Mediterranean onto the North African coast. Arago went ashore and walked to Algiers, evading hostile Bedouins on the way. In Algiers he found that the Regency was in dispute with France over a payment of outstanding import duties. He was taken hostage by the Regent of Algiers, and placed under house arrest.

Several months later, the dispute was settled and in June 1809 Arago sailed yet again towards Marseilles in a fleet of four merchant boats.

His adventures were not yet over. Off Marseilles, Arago was arrested by a Royal Navy warship, the sloop HMS *Minstrel*, enforcing a blockade of Napoleon's France. Three of the ships carried cargo from, and/or were themselves from, countries hostile to Britain (e.g. cotton from Virginia carried in American ships). The ships had been reflagged as neutral Algerian ships, but were not considered genuinely as such by the British captain. They were taken as prizes. Arago's ship was genuinely Algerian but also carried concealed contraband. This was not discovered, nor was Arago's identity as a French official (although if challenged he could produce his passport from the Royal Society) and Arago was again freed. He set foot on the French mainland for the first time in 3 years.

Arago was welcomed back from the dead by his mother in Estragel and returned to Paris in 1809. He was able with a flourish to pull from inside his shirt papers his scientific data, which he had kept safe on his adventures for eighteen months. Home from a scientific expedition more full of incident than most astronomical observing runs, he was feted as a hero for his 'laborious and perilous adventures'. He was immediately elected to the Académie des Sciences head of more able and better-established scientists, such as Poisson. Inspired by his astronomical experiences, he turned away from the army to science.

Arago became scientific director of the Paris Observatory, where he worked on the wave theory of light, particularly its effects on the speed of light in various materials. He invented a photometer, based on crossed polarisers. He contributed to meteorology and oceanology. He became Secretary of the Académie des Sciences, and together with his position at the Observatory he became very influential in the practice of science. It was Arago who invited the Parisian gentry to see Foucault's pendulum ('come and watch the Earth turn in the central hall of the Observatory'), and then arranged to exhibit the pendulum in the Pantheon for the people of the city: it still swings from the Pantheon Dome for the marvel of residents and tourists. It was Arago who arranged for the state to acquire Daguerre's process for photography, so as to make it generally and freely available. It was Arago who suggested to Leverrier that he should investigate why Uranus was off orbit, perhaps pulled by an unknown planet—which indeed it was—a suggestion which led to the discovery of Neptune. Arago also gave frequent and spectacular lectures, and wrote popular books, including *Astronomie Populaire*.

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Arago had been involved in politics from an early time. Even as a student he refused to take an oath of allegiance to Napoleon, but was forgiven by the authorities because he was such an outstanding mathematician. His brothers were local politicians, who later moved with him onto the national arena. Arago became the minister of marine and colonies, and of war, under the Second Republic in 1848. In this role he outlawed corporal punishment in the navy and improved sailors' conditions. His government established universal manhood suffrage and abolished slavery in the French colonies: it was Arago who signed the latter declaration. The government set up national workshops to guarantee work for everyone, as a Keynesian economic measure.

Arago was elected President of the Commission at the head of the Assembly in 1848 and was the Head of State (25th Prime Minister of France) for 46 days. He thus joined a short list of astronomers who held this rank in national politics, including Alfonso the Wise and Ulugh Beg. In this position, however, he abolished the national workshops, which had become unaffordable, and replaced them with conscription. This caused considerable public unrest, more even than a proposal to raise the pensionable age to 62, and as a consequence there were riots in Paris in June and July 1848. Arago was deposed, and returned to work at the Observatory. His beloved Republic did not last and he had to refuse to take an oath of allegiance to Napoleon III in 1852. He retired in 1853 and wrote his memoirs, *Histoire de ma Jeunesse*.

Arago was an average scientist, but he was an inspiring scientific leader. He was clearly a democrat with considerable humanity. He was well meaning as a politician, but unskilled, with a mixed record that included some significant advances in the history of human rights in France. If he had been British and active in recent times, astronomers in Britain would be holding Arago up as an example of how someone can be inspired by his astronomical work to turn to science and its larger aspects, with important political and economic consequences.