Sophie Peel, 1st year (BSc Mathematics)
College of Engineering, Mathematics and Physical Sciences, University of Exeter

Marie-Sophie Germain

Figure 1: An image of Marie-Sophie Germain (©Creative Commons)

Marie-Sophie Germain (1776 – 1831)

Marie-Sophie Germain was a tenacious, influential mathematician in the 18th and 19th century. Not only did she take huge strides for women to be accepted in any scientific capacity, but also significantly contributed to the fields of number theory and elasticity. Whilst never working in a professional capacity, she dedicated her life to her work of mathematics and science. Sophie was the middle of three sisters and born on the 1st of April 1776 into a Parisian bourgeois family. They were relatively affluent through several generations of trade, with her father being a silk merchant and actively engaged in politics at the start of the French Revolution. The revolution started when Sophie was 13 in 1789 and Paris was a very uncertain place to be, so to escape the turmoil, she turned to her father's library where she read Bezout's standard text in mathematics and Montucla's *Histoire des Mathématiques*. She learnt about Archimedes, who was killed by a Roman soldier during the second Punic war, who never stopped his pursuit of mathematics even during his dying moments. This eased her fears somewhat about the revolution, inspiring her to pursue mathematics. Studying, in general, was very unusual for someone of her class and gender, and Sophie's parents were very opposed, but being so strong-willed she studied at night under her blankets. Her parents would make her cold and take away any light to force her to rest.

L'École Polytechnique was opened in 1794 when Sophie was 18 years old. Women were not allowed to attend the Institute, but the lecture notes were made available to anyone who asked. She completed Joseph Louis Lagrange's course and started sending her work to him but, afraid that she would not be taken seriously, Sophie adopted the pseudonym M. Le Blanc - a former student of the Institute. Lagrange saw Le Blanc's intelligence and they exchanged many letters where Sophie revealed her identity, but Lagrange did not alter his respect for her work and even shared this with his colleagues. Lagrange became Sophie's mentor, and she started to correspond with some of his colleagues, although not all of them shared

Lagrange's open-mindedness. For example, Laplace's *Exposition du Système du Monde* was published in 1797 and she started to discuss it with Jérôme Lalande. He thought a woman reading that was inappropriate, and she should be reading his book *Astronomie des Dames* (*Astronomy for Women*), which rightly offended her, containing not one mathematical equation.

One of the most notable things about Sophie was the original work she did. In 1808 the Academy of Sciences in Paris proposed a competition to give a mathematical theory of vibration for elastic surfaces. Despite the fact that she had no formal teaching, she submitted the first entry in 1811, unfortunately containing some mistakes. Enlisting help from Lagrange and Legendre, she got an honourable mention in 1814, but in 1816, she was awarded the medal for her work, although it was not perfect. She did not attend the award ceremony because she felt her work was not appreciated. After her contributions, elasticity got lots more attention along with mathematicians building on her work, and even though she dedicated ten years of her life to it, she was shut out as this was no place for a woman. Simply put, women would not be taken seriously no matter how intelligent or hard-working they were.

Sophie's love of number theory and important research was kick-started in 1801 when Carl Friedrich Gauss published *Disquisitiones Mathematicae*. After three years of research, she sent Gauss her first letter using the pseudonym Le Blanc out of concern she may be dismissed and continued the correspondence for five years up until 1809. Except Gauss found out Le Blanc's true identity in 1806 when the French occupied the town where Gauss lived. She remembered Archimedes' story and contacted a family friend who was a French general to protect him, and uncharacteristically for mathematicians in that era, he praised her more highly upon finding out her gender. After ten years of work in elasticity, she contacted Gauss again, talking about how interested she had been in Fermat's last theorem. Sophie was the first person to present a plan for how to solve the theorem, and although unsuccessful, her work was still important. To this day, we still refer to Germain primes, and she was outlived by her ideas by about 200 years as they were central to the solving of Fermat's last theorem.

Sophie never married and relied on her family money her whole life compared to her sisters, who took more traditional routes. After the youngest sister married a doctor, the Germain family moved into the grand townhouse he owned in Paris shortly after 1816. Sophie was in terrible pain towards the end of her life, being diagnosed with cancer in late 1829 and died two years later in 1831. In her final year, she wrote a paper about her work towards Fermat's last theorem that got published in Crelle's Journal. Six years before her death, Sophie met Guglielmo Libri - a talented young Italian mathematician - when she was 49, and he was 23. They got along instantly and became good friends, writing to each other up until a month before her death about number theory and old mathematical manuscripts that Libri had a great interest in. Sophie as a woman, would never be in a position to further Libri's career, and even when she tried, nothing came of it. Nevertheless, he was very fond of her and wrote a heartful, emotional obituary a year after her death.

The sum of preserved letters, papers, and research is over 200 written pages by Sophie. These pages are of huge importance to mathematics. It is remarkable that her ideas have lasted

almost 200 years, and although opposed by many, her determination has inspired. She is proof of how even a woman is capable of ground-breaking mathematics.

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