Altrincham and District Astronomy Society

Meeting number **619** held on 4th July 2025 at 8pm

Location: Timperley Village Club

Apologies: None

Members Present (in person): 21

PRESENTATION

This was an extraordinary meeting, held because the previous one had been cancelled due to a power cut affecting most of Timperley. Frederico Panichi, who had been scheduled to speak at that meeting, had very kindly agreed to come back in July to give the planned presentation which was entitled "Order and Chaos in the Solar System".

Frederico began by briefly introducing himself and why the topic of "Chaos". He had completed his PhD in celestial mechanics and the topic for his thesis had been on Chaos Theory. He then gave a practical demonstration on order and chaos. He balanced an ever so slightly moving piece of paper on an edge, then walked towards it: the air movement disturbed the paper, initially by only a small amount but ultimately resulting in the paper the falling to the floor. A demonstration of the impact of small perturbations on a dynamic ordered system resulting in significant changes of movement and a chaotic system. Frederico then explained when was meant by the term "order". An ordered system was a moving system, where it was possible to calculate how that system would evolve over time, the example given was a simple pendulum. For a more complex system such as a double pendulum there could be no such solution, it was the opposite of "order" – "chaos".

Frederico then took a step back in time to look at lunar theory. From the 5th century BCE onwards, astronomers had looked at the moon and tried to understand and predict its movements using mathematics. This had continued over the centuries, with many people from many different cultures trying to solve the problem of why the moon behaved the way it did. In the 17th century Isaac Newton used lunar motion to test his second law of motion for a 2-body equation. He found however, that although in theory it traced the orbit of the moon around the earth very nicely, when he used his equations to predict the moon's position at any given time in the future, the predictions didn't match reality. He therefore tried to recalculate using 3-body equations i.e. taking into account the influence of the sun but could not solve his equations. At the time of Newton philosophy, religion and science were all intertwined and so Newton put down the fact that moon appeared to move in an unpredictable fashion to divine intervention. This caused quite a debate, with Leibniz refuting the idea, stating that all physical interactions should be explainable without the need to invoke "god" and an explanation continued to be sought.

Moving on to the 19th/20th centuries Frederico then covered how measurement of this "chaos" had developed. In 1887 Poincaré proved that 3-body problems could not be solved and that small perturbations over time resulted in large differences in outcome. In 1892 Lyapunov introduced his use of exponents to demonstrate that if two nearby points in a system diverged exponentially, the system was chaotic. In 1954 Kolmogorov used approximations to understand that systems could be both stable and chaotic. This explained why some systems that should be chaotic (like the solar system) remain remarkably stable over long periods.

Post 1963 computer visualisation was used to model weather systems, which revealed that tiny changes in initial conditions led to vastly different outcomes i.e. that the weather was a chaotic system. Scientists then applied this visualisation to the solar system, using complex computations with many different perturbations and approximations. Fredrico showed the meeting a z-graph from the 1970s demonstrating how computer plots of variation against time created a butterfly-shaped figure that visualised chaotic motion. In the 1980s z-graphs were further developed into Markus–Lyapunov fractals that provided improved visual representations of chaos and order. Federico showed the meeting a few of these and how they compared to the early z-graph. In 1993 Laskar demonstrated the stabilisation effect of the moon on Earth's oscillations and showed how resonances were the source of the perturbations affecting order.

Post 2000s computers became ever more powerful and were able to show that every system within our solar system was both chaotic and ordered. The Kepler missions extended this and were able to show that this was not unique to our solar system. Frederico concluded the presentation by saying that chaos within the solar system was due to overlapping resonances and that order was due to screening effects that suppressed or modified the influence of these forces. He finished by saying that chaos was a universal property of gravity.

ITEMS OF BUSINESS

1) Future Presentations

There were quite a few gaps in the schedule for next year's presentations and a request was made for suggestions for future topics, speakers and volunteers.

2) Events

- **a)** The Perseid meteor shower was due Aug12/13 and the moon would be only 10/11 days old so viewing would be good. If anyone was interested an observing session could be organised. This would happen nearer the date when the weather was known.
- **b)** The Timperley Country Fair was usually held on 2nd weekend in September where ADAS would have their usual stall. Volunteers for this would be welcome.
- **c)** Ideas were requested for the planned open day on Oct 11. It was hoped to hire the planetarium from the local scouts and run maybe two 20 min presentations on simple topics throughout the day. There would also be a children's corner. Volunteers for speakers and personnel to manage to door were requested. It was also planned to invite the Mayor.

Next meeting

Next meeting 5th September 2025 (AGM)