Supplementary written evidence submitted by Professor Dr M. Kramer (AST0045)

Astronomy funding in Germany

The funding of astronomical research is diverse. Like other research in Germany, astronomy is carried out in different types of institutions. There are about 30 universities where astronomy is taught, although the size of the departments ranges from very small to large (e.g. in Heidelberg or Munich). This research is funded by the German Research Foundation (DFG) and, for the development of instruments, also by the Federal Ministry of Education and Research (BMBF via the "Verbundforschung", now called "ErUM-Pro"). The largest number of full-time researchers are employed by the Max Planck Society (MPG), which carries out the bulk of German astronomy research through those seven Max Planck Institutes that focus on exclusively on a variety of areas of astronomy. Their funding comes directly from the MPG and is given to their directors in the form of essentially guaranteed funding until their retirement. This allows them to take on high-risk, high-reward projects or those that take much longer than the usual funding cycles. The majority of instrument development in Germany, e.g. for the European Southern Observatory (ESO), is carried out by Max Planck Institutes. There are also significant contributions from an astronomy institute in the Leibniz Association. The Helmholtz Association, which is directly funded by the ministry and was originally set up to operate large-scale scientific facilities for the German community, carries out a very limited amount of astrophysics. The lack of a national centre (e.g. set up as a Helmholtz Institute) has resulted in significant disadvantages for German astronomy research for projects that are not carried out in the framework of ESO or ESA. For example, German participation in the Square Kilometre Array has had a difficult history due to the lack of a national institution that could take care of Germany's membership contribution to this new treaty organisation and thus allow universities to participate (apart from Max Planck with its own contributions). The latter situation has now changed drastically with the establishment of the German Centre for Astrophysics (DZA). The DZA has received a funding commitment of €1.3 billion over 10 years to create the first national centre for astronomical research in three main areas (astrophysical research, data science and instrument development). The funding was awarded following a competition launched by the state of Saxony, which received federal funding to transform the coal mining-dominated industry into a 21st century green economy. The DZA successfully demonstrated in the competition that astronomy is a driver of innovation and technical solutions that benefit society and industry on a much wider scale (e.g. in the fields of communications (wifi) or materials science (special glass now used for precision lithography in the production of computer chips)). The DZA is currently built up in Görlitz, near the Polish border. Overall, research in Germany has benefited from the “Pakt für Innovation und Forschung”, a funding commitment upheld by different government since 2004 to increase spending on fundamental research by about 3-4 percent every year. In addition, German astronomers are highly successful in obtaining EU funding, via the Horizon programs or, specifically, via competitive grants from the European Research Council (ERC).

Threat of satellite mega-constellations

The number of satellites launched in recent years has increased dramatically. Mostly launched with the argument of providing commercial internet access to remote areas, the sheer number of satellites expected over the years (a hundred thousand or more) has serious implications for the prospects of astronomy in the future. Indeed, it is possible that the current generation of children will be the last to see the night sky, as satellites not only damage sensitive astronomical telescopes, but also reflect sunlight to such an extent that stars may no longer be clearly visible. Although this is an extreme view, it is not unrealistic.[1] Although the impact on the global ecosystem is poorly understood, it is clear that not only optical astronomy will suffer (e.g. some observations with the Hubble Space Telescope or earth-bound telescopes are already affected). The satellites also communicate via radio emissions that are billions of times stronger than natural radio sources in the universe. Observations that in the past have led to fundamental discoveries in physics and changes in our understanding of the fundamental laws governing the universe may no longer be possible. It is not only the directed radio emission, but also the "radio smog" of on-board electronics that can be picked up by sensitive radio telescopes being built in the most remote areas of the planet to escape the loud noise of civilisation.

It is not the aim to completely prevent the meaningful usage of mega-constellations, even though cost-effective alternatives may exist for many areas in the world. It is about establishing an international legal-framework that controls the degree emission, the frequencies used, and also the orbits so that collisions and the creation of space-debris endangering the general usage of space are prevented. Currently, the efforts are driven by mostly purely commercial interests of a few companies, and no enforceable legal structure exists. Colleagues in Europe, some of us working in my institute, have managed to elevate the topic of mega-constellation to an agenda item in the next UN world radio conference. It is very important that the influential voice of the UK via Ofcom helps in ensuring that also future generations of children can enjoy the wonders of the Universe.

While also some space telescopes are and will be affected by mega-constellations (e.g. the Earth-observing satellite pair GRACE had to fly several evasive maneuvers to avoid collisions), the larges impact will be for ground-based telescopes. But these facilities are not only much more cost-effective, the allow to build instruments that are impossible to be built in space (e.g. the European Large Telescope), but we also need those instruments to allow a wide variety of science and especially training of young researchers.

Role of AI in astronomy

The use of AI has profoundly changed the way we do astronomy in an era where the amount of data is so vast that it is beyond the capacity of humans to handle. A number of scientific questions can be addressed through citizen science projects, but the sheer volume of data that would need to be moved to the user prevents this in most cases. Instead, we need to move our computing resources to the telescope (like in the case of the SKA), and we need to

[1] see e.g. https://andyxlastro.me/losing-the-sky/

use AI to cope with it. In Manchester and Bonn, we started to develop these strategies more than 10 years ago. But there are also dangers: First, the AI needs to be trained, and there is a risk that the AI will only recognise events that it knows about. Instead, astronomy is a discovery science, where the most fundamental discoveries have often been made serendipitously, with other scientific goals in mind (e.g. the cosmic microwave background or pulsars). These discoveries may be missed by AI if it is not used properly. The use of AI is also often energy intensive. We need to ensure that the overall carbon footprint of research, including astronomy, is controlled.

On the other hand, the usage of AI in astronomy also promises large opportunities. Astronomers can develop technique for the handling of huge data streams that can find application in completely different areas. While radio astronomy is facing the largest data volumes and rates already, similar rates will become familiar later somewhere else, e.g., in smart cities. Astronomy data are not subject to privacy concerns, and so my institute has already collaborated with one of the world's largest software companies to provide them with data sets and challenges for their code development.

Public outreach and work with Amateur astronomers

Public involvement in astronomy is very well developed in Germany. Apart from the professional outreach activities of the astronomy institutes, there is a large network of public planetaria and small "people's observatories". There are about 10 large planetariums, each with a staff of about 300, which attract up to 300,000 visitors a year. But there are also about 50 smaller ones that can accommodate about 50 people. The community observatories provide access to small telescopes, and some of them are now coming together in the German Astronomy Telescope Network to share knowledge, software and research. Many of them are organized also in the "Verein deutscher Sternfreunde" (VdS) with organized activities across the country.

But I am also aware of activities in the radio regime where actual research is being done with amateurs. For example, the Stockert telescope, which was briefly the largest telescope in Europe, is now operated by amateurs using equipment from my institute. They have helped to monitor a source called a "magnetar" and this is now part of a peer-reviewed publication.

In the last year, with the help of the ministry, we organized a large inflatable planetarium that travelled through 15 cities in Germany over the summer as "Universe on Tour"[2]. We visited the pedestrian zones of cities to attract people to astronomy who would otherwise not visit a planetarium. Accompanied by a second structure with an travelling exhibition, we made sure that local astronomy colleagues would also be represented, establishing local connections to the public. With this two colourful globes, seemingly having arrived from space, we attracted nearly 60,000 visitors during the 15 stages.

It is very important to attract children to STEM, and astronomy is a very good attractor. Children are fascinated by space. That is why there is a very organised teacher training in

[2] https://www.wissenschaftsjahr.de/2023/universe-on-tour

Germany, with activities in different parts of Germany. The IAU Office of Astronomy for Education is hosted by the “Haus der Astronomie”, which is run by the MPG.

There are also activities with schools. Initially funded by a grant from the ministry, my staff developed an experiment called “Moonbounce”[3] in which we take a 1.2 m radio dish to a school, from which we send Morse code messages to the moon, where the signals are reflected and picked up by our 100 m radio telescope, where we devote observing time and transmit the signal back to the school via a browser application. The children learn the basic concepts of radio waves as another form of light, the speed of light (the round trip takes about three seconds) and distances in space. This programme has been very successful and we will continue to run it.

Qualification and diversity

As in other areas of STEM research, the lack of diversity in German astrophysics needs to be addressed. Progress has been made on gender diversity, for example through the MPG's self-commitment to appoint at least 30% female directors at its institutes. They serve as role models for increasing gender diversity at the lower salary levels as well. More needs to be done, including in ensuring the presence of other under-represented communities, where I consider free higher education as fundamentally essential.

A general problem with gender diversity is the 'leaky pipeline', where female colleagues drop out at earlier stages of their careers. Special programmes such as the MPG's Lise-Meitner-Excellence (LME) programme try to address this. At the national level, the Ministry and the Länder have funded entry-level tenure-track positions, which are now established at several universities. However, the general problem in German astronomy is the lack of tenure-track positions and a clear career path due to the lack of funded permanent positions. Therefore, a forthcoming law that aims to limit the length of the post-doc phase to a maximum of four years (with the years of employment being counted across all institutions in Germany) is seen as counterproductive and even very damaging: Without funding for permanent positions, German young researchers will be forced out of the market and out of the country. In contrary, I do appreciate the clear career track in the UK, starting from lecturer, senior lecturer and reader all the way to full professorship, which I benefited from personally.

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[3] https://www.moonbounce.tel/