Astronomy and Satellite Constellations: Pathways Forward
Proceedings IAU Symposium No. 385, 2026
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doi:10.1017/S174392132400108X

A solution of a Devil's advocate - put telescopes in space

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Abstract. We present a solution of a devil's advocate to put telescopes in space, as one possible way to mitigate the impact on astronomy and on the night sky of recent large satellite constellations. The limitations of telescopes in space versus on Earth are noted. However, the solution draws from the history of telescopes that had to be moved from major human settlements to rural areas in the past; and it poses que question if it is possible that the future may lead to similar moves of putting telescopes in space, as satellites become a major human development similar to human development of cities that pushed telescopes out of cities to rural areas in the past.

Keywords. Space telescopes, satellite constellations, night sky, light pollution

1. Introduction

As one possible way to mitigate the impact on astronomy and on the night sky of recent large satellite constellations, we present a solution of a devil's advocate to put telescopes in space. The solution was partially inspired by a conversation on this subject during a live national radio show in South Africa, called SAfm Sunrise, that was a response to various sounds of alarm raised by astronomers on the topic (e.g. Collent 2023; Falchi et al. 2023; Kocifaj et al. 2023; Venkatesan 2023).

2. From doubt to opportunity to caution

Fig. 1 depicts the SAfm Sunrise national radio show podcast and a selected sample of the science topics it has covered as well as some science questions that have been posed on the show. One of the responses is about one possible way to mitigate the impact on astronomy and on the night sky of large satellite constellations. We present a follow up of this response, a solution of a devil's advocate to put telescopes in space. The initial reaction to this was doubt and then a recognition of the opportunity, though with caution. Why consider this at all? If humans have found solutions for building and operating telescopes far from where many humans live daily and sometimes even in hostile locations, like high altitudes and polar latitudes, why not find similar solutions in space, and at large scale? Space has become the next frontier for humans, and why not embrace it and look not only for bigger commercial opportunities like communication satellites but also for growing science activities there like the next planned Moon missions and more? Well, do it with caution and better set best practice guidelines early, but keep open the doors for more! Fig. 2 shows an example of this, a future telescope in space, i.e. the Xuntian, known as the Chinese Survey Space Telescope or the Chinese Space Station Telescope (CSST), proposed to be serviced in space and upgraded over time. One disadvantage of the telescopes in space has been that unlike those on earth, they

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https://doi.org/10.1017/S174392132400108X Published online by Cambridge University Press



Figure 1. Depiction of the SAfm Sunrise national radio show podcast with a selected sample of the science topics it has covered and insightful science questions posed on the show, including one related to the topic of this paper.



Figure 2. An example of future telescopes in space, i.e. the Xuntian, known as the Chinese Survey Space Telescope or the Chinese Space Station Telescope (CSST), proposed to be serviced in space and upgraded over time (see Xin (2023)).

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can't be serviced regularly and upgraded; however, this space telescope is proposed with that option. Will there be more of these examples in the future, including on the Moon and other planets?

3. Science growth globally

As articulated by Leeuw 2024, the global context of science can be described in episodes on logarithmic scale using selected key moments and representative images from literature. Such an example, from modern times to just over 20 000 years ago, is depicted in Fig. 1. Key in the figure is that both scientific instruments and people are shown at different developmental stages of science. The figure shows the telescopes of Galileo Galilei, that he used to observe the moons of Jupiter. These early telescopes are shown in the context of the development of science and instruments used in that development, including observations of Moon phases and other stars in general by eye before Galileo's telescopes. As adopted from Leeuw 2024, the figure lists some individuals and scientific organizations that also played a role in the development of science, to point out that the development is attributed not just to individuals but also organizations that have been pivotal for developing and operating major instruments for doing breakthrough science. The organizations are listed without trying to be exhaustive and are the Royal Astronomical Society (RAS), National Aeronautics Space Administration (NASA), European Space Agency (ESA), European Southern Observatory (ESO) and Square Kilometre Array (SKA). Some of the major instruments of these organizations, including space telescopes, are shown again without trying to be exhaustive, namely the Herschel Space Observatory (Herschel), James Webb Space Telescope (JWST) † and a dish of the MeerKAT Radio Telescope ‡, a pre cursor of the SKA. The instruments show the development of astronomical instruments that include both land and space telescopes and is what prompted the question that inspired the solution of the devil's advocate presented in this paper.

4. Lessons from southern Africa

One of the oldest modern scientific institutions in Southern Africa is the South African Astronomical Observatory § (SAAO), which was founded in 1820 as the Cape Royal Observatory by the British Royal Society for mapping and studying stars of the southern hemisphere. A photograph of the observatory is depicted in the timeline presented in Fig. 3, as one of the scientific developments some 200 years ago, i.e. around the time of Coulomb in the episode that would later include Maxwell, Hertz and Einstein. This development of an observatory at a place distant from its founders, is certainly a good historical example of the development of telescopes in distant locations from their founders as advanced for space in this paper.

Fig. 3 also shows the Southern African Large Telescope (SALT, Buckley et al. 2005) with its 10m class optical mirror built some twenty years ago and the MeerKAT Radio Telescope with its 64 radio antennae now in its 5th year of operation, that we built in South Africa much later and farther away from the Cape Royal Observatory in Cape Town. In this case SALT is some 400 km from Cape Town, because by the time it was built, the city of Cape Town had grown and the resulting light pollution necessitated the building of the telescope 400 km in rural areas with dark skies and good astronomical seeing. MeerKAT is also 700 km outside Cape Town in a radio quiet location away from the many sources of astronomical radio interference or pollution in the city. The headquarters of both observatories are in Cape Town but the actual observatories are far

† NASA Online Pages, www.nasa.gov accessed 10 March 2024

‡ South African Radio astronomy Online Pages, www.sarao.ac.za last accessed 10 March 2024

§ South African Astronomical Observatory Online Pages, www.saao.ac.za last accessed 10 March 2024

https://doi.org/10.1017/S174392132400108X Published online by Cambridge University Press

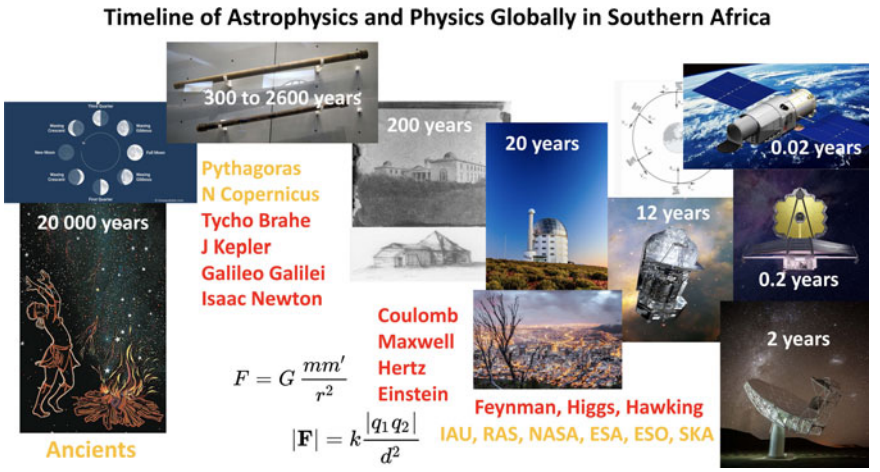


Figure 3. Timeline Depicting the Development of Astrophysics and Physics Globally and in Southern Africa. The timeline is constructed in logarithmic scale from modern times to just over 20 000 years ago using selected key moments and representative images from literature.

from the city. This is indeed another modern example of the solution proposed in this paper of putting telescopes in space away from the light pollution from satellites that interferes with observatories on the ground.

5. Poetic Outlook

The following extract is from poem 'We demand Physics!' by Keith Gottschalk from his book of poems *Cosmonauts do it in Heaven*. The poem is written in response to the Cape Observatory moving from Cape Town to a town in the rural Karoo region about 400 km away from the light pollution in the city of Cape Town. The poem speaks for itself so it's written here without further explanation.

'When the stars fled Cape Town
the astronomers followed
for stars hide in the light
we can only see them
in the brightest dark.'

'We who serve the stars,
left Hartleyvale floodlights,
smog & skyglow to astrologers,
for astrology thrives on opaqueness.'

'Starlight & irony bathe this Sunderland Karoo koppie:
a descendent of British admiralty
now precessed to this desert hill:
tonight, astronomy looks up.'

Below is an adaptation of the poem with the angle presented in this paper of a devil's advocate to put telescopes in space. Again the adapted poem speaks for itself so it's written here without further explanation. In boldface below are the added words to the poem above.

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The adapted title is: 'We demand **astro**physics **beyond Earth**', and the poem follows.

'When the stars fled Cape Town **and the Earth's night sky**
the astronomers **and sky enthusiasts** followed
for stars hide in the light
we can only see them
in the brightest dark.'

'We who serve the stars,
left Hartleyvale floodlights **and the Starlink satellite constellation streaks**,
smog & skyglow to astrologers **and youtubers**,
for astrology thrives on opaqueness **and social media on trends and streaks**.'

'Starlight & irony bathe this Sunderland Karoo koppie, **Earth Orbits and the Moon**:
a descendent of British admiralty, **of NASA and Space X Exploration**
now precessed to this desert hill, **to space and the Moon**:
tonight, astronomy looks up, **to telescopes beyond Earth**.'

6. Summary

It is noted again that the alternative solution of a devil's advocate to put telescopes in space, as one possible way to mitigate the impact on astronomy and on the night sky of recent large satellite constellations, is presented here deliberately to provoke discussion rather than as a final solution. Some of the limitations of telescopes in space versus on Earth are pointed out and discussed. As noted, the solution draws from the history of telescopes that had to be moved from major human settlements to rural areas in the past, with lessons from Southern Africa; and, asks, if it is possible that the future may lead to similar moves of putting telescopes in space, as satellites become a major human development similar to human development of cities that pushed telescopes out of cities to rural areas in the past. The presentation ends with a poetic outlook that showcases an earlier poem 'We demand Physics!' by Keith Gottschalk and adapts here as 'We demand **astro**physics **beyond Earth**.'

7. Acknowledgement

Lerothodi Leeuw (LL) funding from the South African National Foundation.

Some historical records presented here are critically adopted from the Southern African Astronomical Observatory (SAAO), Square Kilometer Array South Africa (SKA SA), Astronomical Society of Southern Africa (ASSA), and International Astronomical Union (IAU) and Royal Society.

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