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Inclusive Astronomy and Science in Africa and other Non-Western Regions for the Global Benefit

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Abstract. This paper presents a narrative for making astronomy and science inclusive in Africa and other non-western regions for a global benefit. With a recognition that most modern astronomy and science are written in textbooks and taught in schools and university in a Euro-centric focus that only acknowledges contributions from prescribed scientific periods in modern European civilization, an alternative is presented with a broader acknowledgement. The inclusive benefits for the alternative are discussed, not only for the target people that would have been previously excluded but also a broader audience that are likely to gain from the broader and thus deeper reaching presentation.

Key words. Education: Astronomy, Science, Inclusive, Public outreach and communication

1. Introduction

Cultural or *indigenous* astronomy has been a subject of many previous studies, including studies that focused on *cultural* or *indigenous* astronomy in Southern Africa or the African continent broadly (e.g. Urama & Holbrook 2011; Medupe 2014). There has also been work on *indigenous* knowledge systems and Western science with application to Science Education (e.g. Ogunniyi 2005; Le Grange 2007; Lee 2020) or intersections and the history of astronomy in Southern Africa and the International Astronomy Union (Leeuw & Holbrook , 2019).

This paper presents a narrative for making astronomy and science inclusive in Africa and other non-western regions for a global benefit. Given that most modern astronomy and science are written in textbooks and taught in schools and university in a Euro-centric focus that only acknowledges contributions from prescribed scientific periods in modern European civilization, an alternative is presented with a broader acknowledgement. The paper is organised to start by presenting an introduction of the global context of science, with a special focus on physics and astronomy (Section 2), then cases inclusive of Southern Africa (Section 3), global *indigenous* knowledge (Section 4), juxtaposing the *indigenous*, Western and Modern (Section 5), and finally encompassing ancient humans in the depths of time and humans globally today (Section 6).

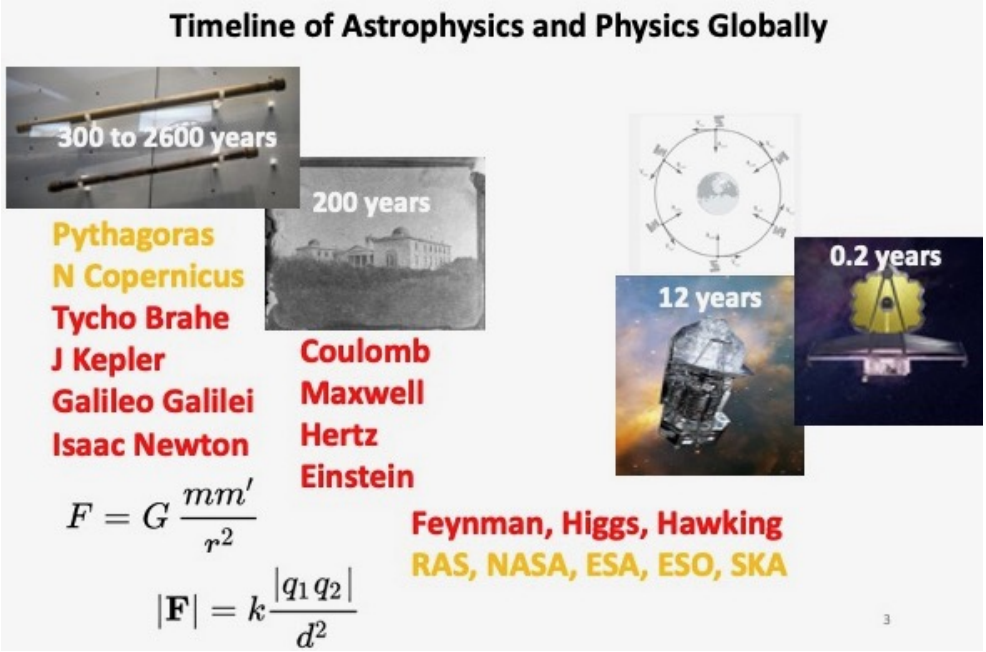

Fig. 1. Timeline Depicting the Development of Astrophysics and Physics Globally. The timeline is constructed in logarithmic scale from modern times to just over 2000 years ago using selected key moments and representative images from literature. The presented timeline is a framework that can be adopted and localised with episodes, stories and images from *indigenous* knowledge developed in other parts of the world.

2. Science Global Context

The global context of science can be described in episodes on logarithmic scale using selected key moments and representative images from literature: a first example, from modern times to just over 2000 years ago, is depicted in Fig. 1. It is noted that the presented timeline is a framework that can be adopted and localised with episodes, stories and images from *indigenous* knowledge developed in other parts of the world. Key in Fig. 1 is that both scientific instruments and people are shown at different developmental stages of science. The main takeaway message is that science is not only about the development of instruments but involves people, and an equitable and fair representation of people involved globally is important when presenting science inclusively. That recognition is important in this paper, and thus as this timeline is used as foundational framework of our paper it will be further developed to be more globally inclusive.

As a start, Fig. 1 shows the standard Euro-centric development of science from Pythagoras to the Copernicus Revolution some 2600 and 500 years ago, respectively, and then later Tycho Brahe's observations of planetary motions that provided Kepler data to construct the Keplerian Laws that would subsequently be used by Newton to develop the Laws of Motion and Law of Universal Gravitation. Fig. 1 also shows the telescopes of Galileo Galilei, that he used to observe the moons of Jupiter. Those observations helped Newton to generalize his Law of Universal Gravitation beyond Earth and its Moon, in recognition that the moons of Jupiter followed the same law in their orbits around Jupiter. Two hundred years ago Coulomb would develop Coulomb's Law of Electrical Charges, following the distance in-

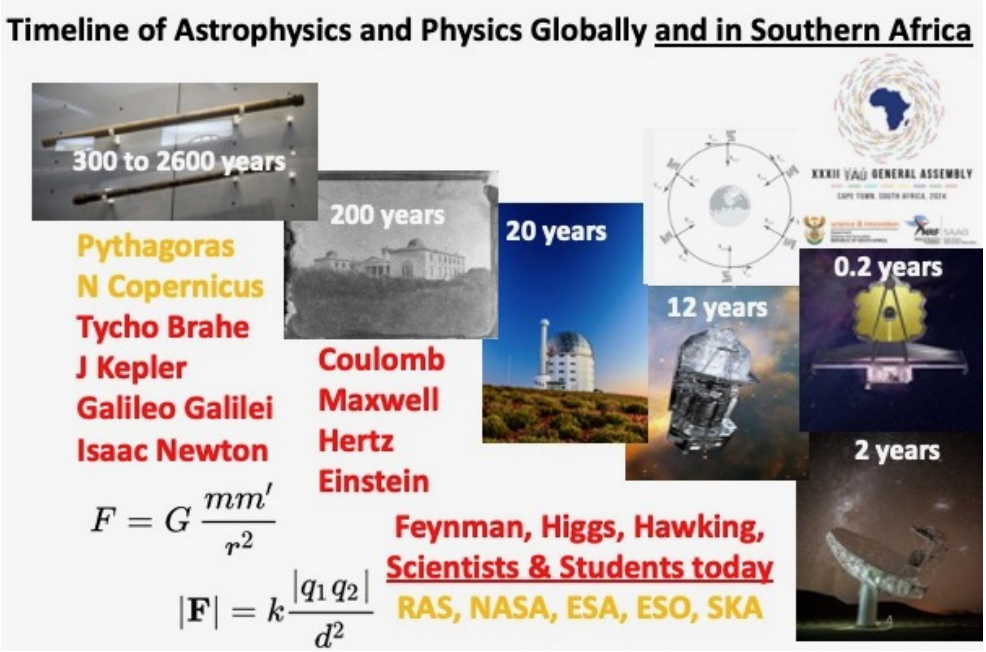

Fig. 2. Timeline Depicting Development of Astrophysics and Physics Globally and in Southern Africa. As in the caption of Fig. 1, the timeline is constructed in logarithmic scale from modern times to just over 2000 years ago using selected key moments and representative images from literature.

verse square relation of Newton's Law of Universal Gravitation, and usher in the physical description of the second of four key forces of nature known today.

Fig. 1 includes names of some key scientists following Coulomb, i.e. Maxwell, Hertz, Einstein, Feynman, Higgs and Hawking. The names are listed without trying to be exhaustive but rather to show a sample of people who played a role in the progressive development of science, focusing on physics and astronomy, to modern times. Finally, the figure lists some scientific organizations that also played a role in the development of science, to point out that the development is attributed and not just by individuals but also organizations, that have been pivotal for developing and operating major instruments for doing breakthrough science. The organizations are also listed without trying to be exhaustive and are the Royal Astronomical Society (RAS), National Aeronautics Space Agency (NASA), European Space Agency (ESA), European Southern Observatory (ESO) and Square Kilometre Array (SKA). Some of the major instruments of these organizations are also showed without trying to be exhaustive, namely the Herschel Space Observatory (Herschel)[1], James Webb Space Telescope (JWST) and a dish of the MeerKAT Radio Telescope [2], a precursor of the SKA.

3. Inclusive of Southern Africa

One of the oldest modern scientific institutions in Southern Africa is the South African Astronomical Observatory [3] (SAAO), which was founded in 1820 as the Cape Royal

[1] NASA Online Pages www.nasa.gov accessed 10 March 2024

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

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

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 Fig. 1, as one of the scientific developments some 200 years ago, i.e. around the time of Coulomb in the the episode that would later include Maxwell, Hertz and Einstein.

Although Southern Africa has been geographically active for more than 200 years in modern science, through institutions such as the SAAO or the Cape Royal Observatory as it was called then, the more recent activity has been driven with a strong participation by local South Africans. Some world-class scientific infrastructure in this activity includes the Southern Large Telescope (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. This activity is depicted in Fig. 2 under the modern episode of globally scientific development lead by the likes of Feynman, Higgs, Hawking and current scientists and students globally. This figure also features the logo of the International Astronomy Union General Assembly [4] (IAU GA) 2024 to happen in Cape Town, South Africa, the first ever IAU GA to be held on the African continent.

The important point of introducing the activities of the Southern Hemisphere here is because they are often ignored when documenting the development of science globally. It is actually significant that it is the scientific activities of the Southern Africa that is being introduced and not just the Southern Hemisphere. In doing so, the role of scientific activities of Africa is claimed among the activities of scientific development globally.

4. Inclusive of Global *Indigenous* Knowledge

It is worth noting that Galileo only developed the telescope some 400 years ago, and before that celestial objects were observed with the human eye as the main instrument. This instrument was available to all humans across the globe before antiquity to observe and certainly marvel at celestial objects. Observations of the Moon and its use for time keeping is certainly evident in languages across the globe. If one considers science as a systematic observation out of which scientific theories emerge, observations of the Moon and its use for time keeping based on theories of its orbital motion must mark some of the foundations of science. Fig. 3 extends the timeline of scientific development beyond the time of Copernicus and even Pythagoras some 2600 and 500 years ago, respectively, to recognize the science and scientific foundations that preceded them, globally.

It is noted *indigenous* is a problematic or at the very least ambiguous term. So ambiguous is the term one of the going definitions is that indigenous is best self-defined and someone else should best not designate another as indigenous unless they do so themselves. Another definition, such as used by the United Nations [5], refers to indigenous as pre-colonial, and if this is in reference to western colonialism, then indigenous must mean non-western or non-colonizer. The paper uses *indigenous* in a way it is normally used for non-humans species; and, that usage usually has to do with time, origin or natural occurrence. Thus the paper uses *indigenous* to refer to a period globally, before Copernicus, and possibly also before Pythagoras, or more broadly to human and scientific ideas that existed outside and before the scope of the ideas typically attributed to Copernicus and Pythagoras. Those of course include the observations of the Moon and its related time keeping and orbit theories as mentioned above; and these are evident in languages globally and should not be contentious. All this is again worthy and important mentioning because it is often not in the general presentation of scientific development and *indigenous knowledge* is often presented as not part of scientific development and practise.

[4] International Astronomy Union General Assembly 2024 Online Pages https://astronomy2024.org/ last accessed 10 March 2024

[5] United Nations Online Pages www.un.org last accessed on 10 March 2024

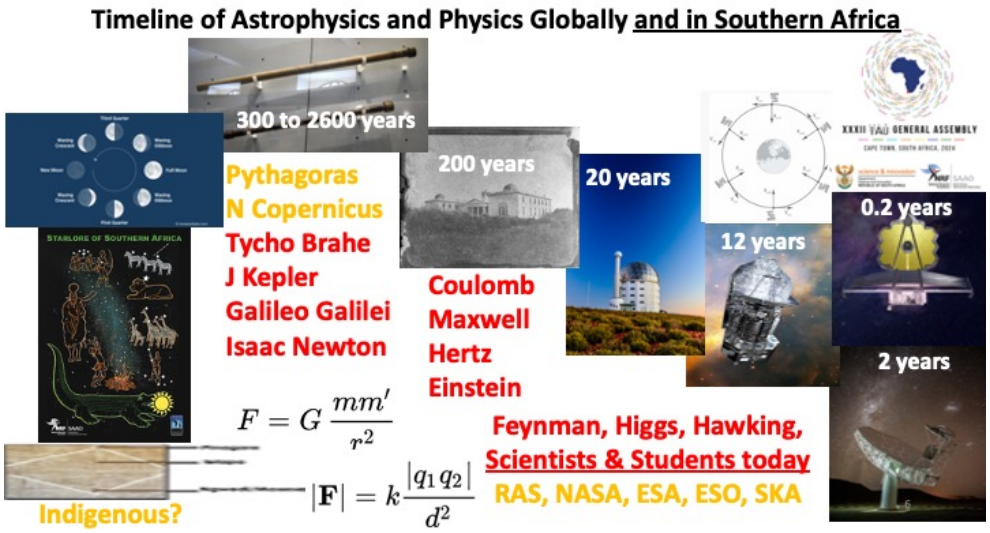

Fig. 3. Timeline Depicting Development of Astrophysics and Physics Globally and in Southern Africa inclusive of *global indigenous* knowledge. As in the caption of Fig. 1, the timeline is constructed in logarithmic scale from modern times to just over 2000 years ago using selected key moments and representative images from literature.

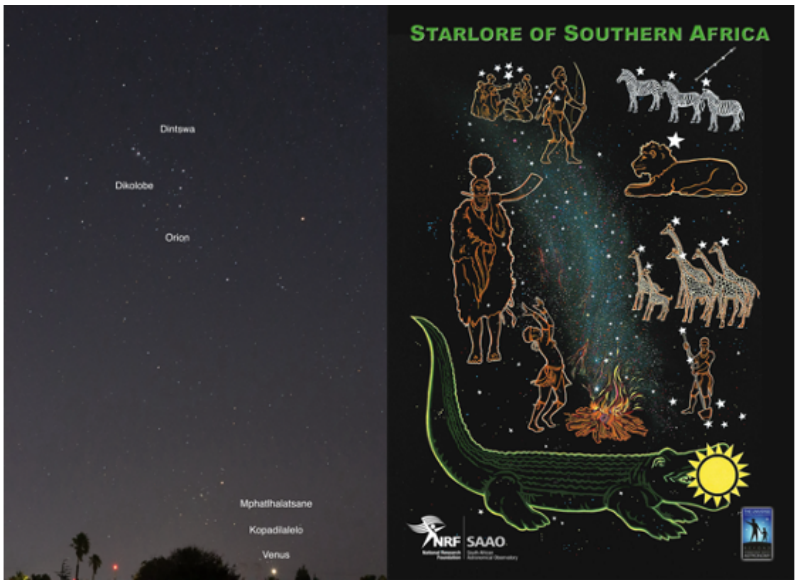

Fig. 4. Juxtaposing the *indigenous* or non-western and western or modern astronomical names in panels of knowledge that is sometimes called *indigenous* or starlore in an attempt to characterize it as non-scientific together with knowledge or images considered western or modern. The depiction uses images from literature (Credit: NRF, SAAO) as well as new images generated by the author.

5. Juxtaposing the *Indigenous*, Western and Modern

Fig. 4 juxtaposes the *indigenous* or non-western and western or modern astronomical names in panels of knowledge that is sometimes called *indigenous* or starlore. Like *indigenous*, the term *starlore* is sometimes used in an attempt to characterize some knowledge spheres as non-scientific. The example here is great because the name Orion, which comes from Greek mythology, is used in science and not called indigenous or starlore, and yet non-western names that also come from equivalents of mythology are often classified as non-scientific names. The name Venus, which also comes Greek mythology, is a further example used here juxtaposed with the Setswana names for Venus, Mphatlalatsane and Kopadilalelo, when respectively seen in the morning and evening skies.

Fig. 5 shows images of the MeerKAT Radio Telescope in South Africa and an image of *Molagodimo*, or in English the Milky Way Galaxy, made from data observed with MeerKAT. The Setswana name of the Milky Way is intentionally used here to claim its place which is rarely staked though it is equal to the English name that is commonly used in literature. The use of *Molagodimo* here is perhaps even more significant than the Setswana names used in Fig. 4, because the image here is actually the deepest image of the central parts of the Galaxy in radio wavebands and probably one of the best astronomical images of the Galaxy in all wavebands and was taken by a telescope in South Africa where people speak Setswana. This therefore underscores the message of this paper for making astronomy inclusive beyond the traditional western norms, because its very development is beyond western boundaries, and this inclusivity is also for western benefit.

6. Inclusive of Ancients in the Depths of Time and Humans Globally Today

The paper concludes with Fig. 6 that extends the timeline depicting the development of astrophysics and physics globally and in Southern Africa inclusive of ancients in the depths of time some 20 k and 200 k years ago, as well as humans globally today. As with Fig. 1, the timeline is constructed in logarithmic scale from modern times to just over 2000 years ago, and then 20 k and 200 k years ago, using selected key moments and representative images from literature. Here there are episodes stretching the breadth of human existence and evolution or development some 20 k and 200 k ago and then back to modern times some 0.2 years ago and the future.

The chief goal in showing this deep arch of time is to underscore the deep origin of science and its roots in the existence and development of humanity itself. Some 200 k years ago humans controlled fire (Gowlett , 2016), by manipulating the theoretical elements of air, fuel and heat that make it, setting forth the path of human development that spurred ancients to modern humans. The fire would be used to protect humans from predators and allow them to make ever more nutritious meals that lead to bigger brain development. In time, they would use the same ideas of fire, its light and heat to develop theories of how stars in the distant cosmos may themselves have been born and evolved (Holbrook , 2009). This is shown in an episode that may have occurred some 20 k ago. The Khoisan legend is that *Molagodimo* or the Milky Way was formed when a girl took burning coals of the fire and threw them in the sky (Holbrook , 2020). Nuclear fusion (Bethe , 1939) was not known then and the going theory was that light comes from fire, so a very good connection of the practical observation and theory, what science is. Paintings in caves have been dated to 40 k years ago showing this developed human ideas of the ancients and so thus the approximation of this episode with the legend.

The images in Fig. 6 include modern humans with some of the most inspiring and inclusive astronomical activities in terms of (1) the MeerKAT Telescope dish that is part of the Square Kilometre Array project, i.e. the largest astronomical observatory on earth, that is being constructed in South Africa, (2) the James Webb Space Telescope, i.e. the biggest astro-

Fig. 5. The MeerKAT Radio Telescope in South Africa and an image of *Molagodimo*, or in English the Milky Way Galaxy, made from data observed with MeerKAT (Heywood et al. , 2022). The Setswana name of the Milky Way is intentional used here to stake its place which is rarely claimed though it is equal to the English name that is commonly used in literature. The images are adopted from literature. Credits: SARAO.

nomical Observatory in Space, and (3) crew of the next human exploration to the Moon, that includes the first woman and African American to go to the Moon [6]. The diversity and inclusivity of these modern scientist activities says more than words can capture and speak volumes for the message of this paper.

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[6] NASA Online Pages www.nasa.gov accessed 10 March 2024

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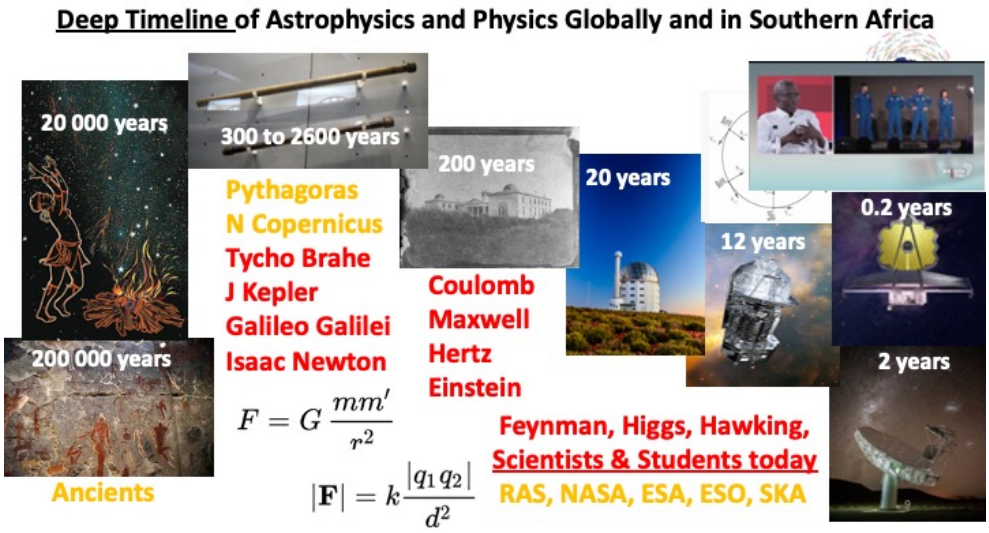

Fig. 6. Timeline Depicting Development of Astrophysics and Physics Globally and in Southern Africa inclusive of ancients in the depths of time some 20 k and 200 k years ago as well as humans globally today. As in the caption of Fig. 1, the timeline is constructed in logarithmic scale from modern times to just over 2000 years ago, and then 20k and 200k years ago, using selected key moments and representative images from literature.

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