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What is the Space for "Place" in Social Studies of Astronomy?

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Abstract All large-scale telescope facilities are constructed within a geographical, social, historical, and political context that includes nested layers at the global, national, and local levels. However, discussions about the geographic siting of astronomy facilities, for example, the communities in which they are embedded or the interactions between the facility and its locale, are uncommon in social science studies of astronomy, and no extant review focused on this gap in the literature. In this literature review and discourse analysis, we explore the ways in which research about astronomy facilities and their local communities has emerged, and the extent to which it focuses on the Global South. We find that literature addressing the social and policy aspects of astronomy facilities has an emphasis on the Global North. However, literature addressing host communities has an emphasis on the Global South. Broadly, the discourses related to host communities in the Global South have emerged from reflections on the controversies related to large-scale telescopes in Hawai'i, Chile, and South Africa. One common theme linking these discourses is that a focus on benefits at the national and international levels obscures a range of problematic power dynamics and outcomes at the local level. The notion of the Global South as an 'empty space' in which astronomical observation does not constitute impactful action amongst local communities, is challenged by discourses that centre local contexts, and challenged by discourses that employ conceptual frameworks with a focus on revealing power dynamics.

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Introduction

There is increasing recognition within the institutions of science, within policy-making communities, and among the public, that science needs to account for itself – it needs to demonstrate positive social impact and be responsive to the perceptions and needs of the communities in which it functions. At the same time, questions about inclusivity and power relations, particularly with respect to global and local inequalities, are being directed at the institutions of science. This is particularly the case with respect to 'big science', where large-scale infrastructure investments, significant policy trade-offs, and broad socio-economic impacts, all amplify demands for understanding and assessing impact.

In the domain of astronomy, as a paradigmatic example of 'big science', large infrastructures face an additional layer of complexity. Whereas infrastructures such as particle accelerators or fusion energy research centres are often located in the Global North, astronomy is incentivised to position large telescopes in the Global South, which faces the galactic plane, enabling observation of the Milky Way. Consequently, astronomy facilities are often characterised by a distinct power relationship: science infrastructure are built and owned by institutions of the Global North, but are increasingly geographically placed in the Global South, and thereby in direct relation with local communities in developing country contexts.

As pressure continues to be exerted upon astronomy facilities to demonstrate their impact, the question arises: what forms of relation exist between these facilities and their host communities? No extant literature review has explored how the social science and policy literatures address this question. This critical gap in the research landscape limits the extent to which case studies can be contextualized in ongoing international discourses and limits the coherence of theoretical advances. To address this gap, we embarked upon a literature review to assess the state of the art with respect to understanding the localized impacts of astronomy infrastructures, and to more clearly delineate the discourses present within the related social science and policy literatures. The core research questions guiding this effort were: (1) How much of the Science, Technology, and Society (STS) and science policy journal literatures on large astronomy facilities has focused on the Global South? (2) To what extent have these literatures focused on host communities? And (3) How can we characterise the discourses present in these literatures?

Methodology

Our literature review employed a purposive exploratory approach. We did not conduct a systematic review, although this is recommended as an avenue for further research. Our review therefore forms a basis for the exploration of evolving discourses but does not represent a comprehensive overview of the literature and does not make claims that apply to the literature as a whole. We focussed on two main

literatures, each providing unique insights into how astronomy and its host communities in the Global South are positioned within social scientific discourses. Firstly, the STS literature presents a disciplinary focus on the interplay between science and society. Secondly, the science policy literature presents a focus on the ways in which social science has informed astronomy-related policy. Taken together, these two strands of the literature present insights into the theory, policy, and practice emerging from social scientific analysis of the impacts of astronomy.

The first step in the review was the sourcing of relevant English-written literatures using defined search parameters and methods. For the purposes of this article, we focused on literature published in academic journals. In so doing, we could better target our searches through comprehensive online databases. We identified the highest ranked STS journals and research policy journals. Using these comprehensive online databases, we drew down papers from the last fifty years (1971–2022) with the following search terms in the title, abstract, or key words: astronomy, astronomical, or telescope. However, amongst these journals, the specific issues salient to our research focus were rarely present. We therefore made recourse to some journals outside of the usual scope of high-ranking STS and research policy journals. One significant addition to our literature collection was a special issue of a journal primarily focused on anthropology and related interdisciplinary work, but in this instance dedicated to a focus on the Square Kilometre Array telescope in South Africa. A second addition were various articles published in Nature which, though not exclusively dedicated to science in society discourses, does publish significant articles on the topic. Cumulatively, the search rendered 78 documents, which formed our literature review database. While this sample cannot be said to be representative of knowledge production in this area, it does provide meaningful insights into the emergence of our focus topics in the key sites of knowledge production, and beyond.

The next step was the development of a coding framework. The process was both inductive and deductive, starting with an unpacking of the research questions, and later adapted to accommodate themes and ideas emerging from the review. In our assessment of each journal article, we applied the following coding questions, in each case summarizing key information about scope and discourse: (1) Focus on facilities in Global North? (2) Focus on facilities in Global South? (3) Focus on host communities in the Global North? (4) Focus on host communities in the Global South? (5) Theoretical framework, (6) Empirical scope (e.g. geographical scope, chronological scope); Key findings and arguments; (7) Recommendations (if present, for either policy or further research).

The coding process had two phases. The first phase focussed on capturing bibliographic data and differentiating between the Global North and the Global South. Articles with a substantive focus on host communities in the Global South were included in phase two, where the aim was to gain insight into the discourses focused on this topic. Following a pilot phase, in which the coding database and methods were tested, each document was reviewed, and its coding captured in a database. The database allowed for the summary and analysis of coding data. Analysis firstly focused on establishing the main parameters of the literature, examining summative data describing the literature and its discourses. The second phase of analysis took

a more qualitative approach, exploring some of the key themes and ideas emerging from the review.

South and North

The selection of eighteen articles that moved into the second phase of analysis, due to their focus on host communities of the Global South, was preceded by reflection on the definition of 'Global South'. The most significant question was that of Hawai'i. Hawai'i forms part of the United States as the "Fiftieth State" and, hence, could be seen as part of the Global North. However, within a broader historical and political context, Hawai'i's relationship with the United States is characterized by dynamics that are more closely aligned to the notion of the Global South—a long history of colonial rule marked by racial regimes, segregation and distancing of Indigenous knowledges, and imposed government structures (including through armed intervention). We have followed here the Global North/South distinction used by Janet M. Conway to "denote geographies of global inequality rooted historically in the European conquest of the Americas and Europe's later colonial domination on Africa, great parts of Asia, and the Middle East" (Conway 2013: 164). As she further notes, "there is a south in the north" and there is a "north in the south", illustrated in the former as marginalized and racialized minorities residing in the North and, in the latter, as the emerging elites of the middle and upper classes in emerging economic countries such as India and Brazil. The violent colonial history of Hawai'i, marked by the arrival of James Cook and accented by the overthrow of the Hawaiian royal family through United States' military intervention, and the subsequent settler violence towards kānaka maoli, substantiate our choice to understand Hawai'i as part of the South.

The use of a Global North/South conceptualisation has both strengths and weaknesses. The flexible and abstract nature of the concept means that we can bend the category of 'Global South' well beyond geographical boundaries to discuss the reaches of empire, colonial histories, racial difference, and segregation. However, it also creates risks of essentialization and blanket statements about the nature of North-South relations. Are the cases of Chile, Hawai'i and South Africa truly as analogous as they seem, or does bundling them together under a single category create the illusion of that being so, while obscuring local differences in the resistance practices and reactions of host communities? As Palomino points out, if Global South is meant to serve as an abstract, subjective counterpoint to dominant European modernities and ways of life of global elites, does a lumping together of these diverse ways of being, living, and thinking not effectively *reinforce* "the ethnocentric reason that was the target of the critique" (Palomino 2019)?

With these considerations in mind, and in order to develop a heuristic that leads to meaningful contextualized analysis, Hawai'i was placed in the Global South category. Analysis proceeded with the recognition that the concepts of Global North/South have the potential to obfuscate questions of *place*, *locality* and *host community* for infrastructures of astronomical research but also have the potential to bring

into focus social and historical dynamics that are essential for making sense of local context.

Results

Publications

A small set of journals produced the majority of publications in our database. Of these, the most productive was *Social Studies of Science*, followed by *Technology and Culture*, *Nature*, *Research Policy*, and *Minerva*. The *Journal of Southern African Studies*, an anthropology journal, also stands out, although this is based on a single special issue (Table 1).

Evolving Discourses 1978–2022

Publications that address the social or policy dimensions of astronomy have become more common over time, although this overall increase is characterised by spikes and troughs that in some cases correspond with attention to specific contemporary issues. The earliest reading in the database was Norton (1978), on 'The Social Origins of Scientific Innovation'. The paper has a primary focus on science facilities and infrastructures, but, significantly, also explores the perspectives of astronomers and the scientific community with regard to the ways in which astronomical infrastructures impact on surrounding communities (in this case, in the Global North).

The first spike in publication activity occurred in 1983, with the publication of Martin and Irvine (1983), Irvine and Martin (1983), and Gieryn and Hirsh (1983). The collaborative papers of Martin and Irvine focussed primarily on the assessment of basic research, and specifically on the Isaac Newton telescope. In this effort, assessment of the impact at the local community level was raised but given marginal attention within the overall focus on scientific achievement and

Table 1 Journal of publication

Journal name	Number of articles
Social Studies of Science	15
Technology and Culture	12
Nature	10
Research Policy	10
Minerva	9
Journal of Southern African Studies	7
Nature Astronomy	5
Science and Public Policy	5
Science, Technology, and Human Values	2
Environment and Planning D	1
Tapuya	1

economic impact. However, Martin and Irvine (1983) do develop helpful insights about the use of indicators to assess the impact of astronomy facilities. The work of Gieryn and Hirsh gives some consideration to the local impact of science infrastructure (in the Global North context). However, its primary focus is on the concepts of marginality and power dynamics within the institutions of science, and the role they play in the context of scientific and technological change. While the paper does not add a great deal to our understanding of the local impact of astronomy, it can be considered an early work within the slowly emerging discourses addressing the roles of power in astronomy.

The second increase in publication activity was over the period 1999–2001. One critical work during this period was McCray (2000). As is the case in Gieryn and Hirsh, McCray published in *Social Studies of Science*, and also considered issues of power and science, in this case using the heuristic of the 'moral economy' of astronomy. While the paper does not give consideration to local host communities, it does reflect on access, equity, control, and authority within local astronomical communities (rather than host communities), and the ways in which these dynamics have an impact on the performance of science and the advancement of knowledge.

A third increase occurred in 2014 and 2015, driven by five publications in *Nature*, which all reflected on the contestation between local communities and the developers of the Thirty Metre Telescope. At the same time, a critical voice emerged regarding the impact of astronomy on local communities in Chile (Barandiaran 2015). This period therefore marks an inflection point, not only with respect to the scale of research focussing on the local impact on astronomy, but also on the formation of advocacy positions and discourses that more critically assessed the power dynamics inherent in the development of large astronomy facilities in postcolonial contexts.

The period 2019–2022 saw a marked increase in publications. The spike in 2019 is largely due to the inclusion in the database of a special issue focussed

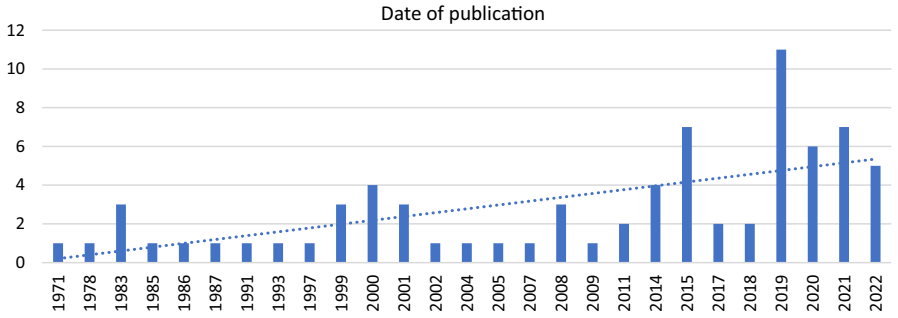

Figure 1 Date of publication

on the local impacts of the SKA telescope in South Africa. However, the overall

growth in publications during this time signals growing academic and advocacy interest in better understanding the social aspects of astronomy facilities (Fig. 1).

Facilities and Communities in the Global North and Global South

Analysis along two main dimensions provides a taxonomic breakdown of the focus of the literature. Firstly, articles can focus either on the Global North or Global South. Secondly, we differentiate between foci on science facilities and host communities, respectively. Within this, we can further differentiate between articles that have these areas as a primary focus, and those for whom they are a secondary or marginal focus. Through this, we gain an overview of where the selected literatures are placing their focus regarding social aspects of astronomy.

At the aggregate level, the literature was fairly evenly split in its focus on the Global North and the Global South. This may be related to the geographical footprint of astronomy facilities, which, unlike other large-scale science infrastructures, have a substantive footprint in the South. The literature addressing Global North facilities was greater than that for the Global South (49 and 35 publications, respectively). The literature addressing host communities was, on aggregate, equal in size but not equal in scope. The literature with a primary or substantive focus on host communities had a significantly greater focus on the Global South (18 publications) versus the Global North (5 publications). Conversely, a higher proportion of publications with host communities as a secondary or marginal focus was seen for the Global North (Table 2).

Host Communities in the Global South

Eighteen publications had a primary or substantive focus on the impact of astronomy facilities on host communities in the Global South. In this, Hawai'i was included as a postcolonial context, and thus within the broad definition of Global South—we address the reasoning and analytical consequences of this choice in a dedicated section above. It should be noted that this distinction is significant, as Hawai'i is the geographical focus of eight of the 18 publications. Taken together, this set of

Table 2 Focus of publication

	Global North facilities	Global South facilities	Global North hosts	Global South hosts
Primary focus	25	20	4	13
Substantive focus	7	6	1	5
Addressed but not primary focus	3	1	13	2
Marginal focus	14	8	59	57
Total	49	35	77	77

publications makes up the core discourse related to the specific issue of host communities in the Global South.

This set of publications is marked by a clear periodisation. The first period of activity is characterised by a set of five articles in *Nature*, all published between April and October 2015, focussing on the controversy surrounding the Thirty Metre Telescope. The TMT is a US$1.5-billion project, in which power is vested primarily in Global North institutions, albeit with Global South government partners. The international consortium governing the telescope is lead by the University of California and the California Institute of Technology, in partnership with the governments of China, Japan, India and Canada. The telescope is being built on Mauna Kea, an alpine telescope complex which already houses a number of smaller telescopes. However, in Hawaiian culture, Mauna Kea is a sacred place, representing where the earth mother and the sky father met, leading to the birth of the Hawaiian Islands. The clash between protesters and authorities centres on their distinct cultural values, in which protesters aim to preserve their cultural values and heritage, on the one hand, and scientific institutions, aligned with government authorities, aim to develop astronomy infrastructure on the island, on the other.

Construction began in April 2015 but was interrupted by protestors blocking construction vehicles from reaching the mountain summit. Witze (2015a), publishing in *Nature*, covers the protest of 21 April 2015, in which hundreds of protestors held a street demonstration in Honolulu. Despite a seven-year process of environmental and legal review, ultimately leading to formal permission to process, Hawai'i's governor declared a temporary construction moratorium while dialogue between protestors and authorities unfolded. Witze (2015b) continued to cover the unfolding contestation. In May 2015, the construction moratorium was lifted, but under the condition that a quarter of the existing telescopes on the site be decommissioned by the time the TMT starts operating. In July and August 2015, contestation emerged again (Witze 2015c). Protesters occupying Mauna Kea were arrested, and further protests took place in Honolulu. In October 2015, Witze (2015d) published a more detailed analysis, foregrounding the voices of local Hawaiians. A protest leader argued that, 'Before you look into space, you need to respect this place' (Witze 2015d). However, counterpoints to this position are also presented, including voices of support from Hawaiian astronomers, international astronomers working in Hawai'i, and scientists working to bridge the gap between the astronomy communities and protester groups. Witze continued to publish in Nature, focusing on the re-starting of construction in 2019 (2019a), and the associated shut-down of other telescopes (2019b, 2022).

In a similar period, cognate dynamics played out in other parts of the world, attracting the attention of social scientists. Barandiaran (2015), publishing in *Minerva*, focussed on the local impact of astronomy in Chile, arguing that astronomy facilities reproduce hierarchies that perpetuate dependency, and retain power in the hands of Global North institutions. Against the backdrop of a historical analysis that explores the history of astronomy in Chile, Barandiaran observes contradictions between discourses emerging from government and scientific institutions, on the one hand, and the development needs of host communities, on the other. Official discourses foreground science and technology transfer as a motor for economic growth,

leading to policy support for astronomy facilities. However, while foreign science benefits from these policies, Barandarian argues that the local benefits are limited by the authoritarian nature of state decision-making, and that host communities are literally left in the dust: 'Each day astronomers drive to the telescopes—some of the most technically advanced machinery on earth running at exacting standards of precision and efficiency—to uncover fundamental truths about the universe; yet the drive is along a dirt road on which barefoot children play. They live in makeshift homes and attend precarious schools though they live in Chile, Latin America's richest economy. Such poverty alongside the telescopes prompts many South American scientists to wonder about their proper role in society and how their countries benefit from their work' (Barandiaran 2015: 142).

While the 2015 spike in attention to astronomy host communities in the Global South was focussed on Hawai'i and Chile, the second increase in 2019 emerges from the publication of a special issue of the *Journal of Southern African Studies*, which focussed on the Square Kilometre Array (SKA) radio telescope in South Africa, which had also encountered resistance within the host communities surrounding the telescope. Unlike optical telescopes, radio telescopes consist of geographically dispersed arrays of radio dishes, and thus can occupy large tracts of land. In the case of South Africa, the arid high-altitude Karoo region is host to the SKA. However, the construction process surfaced a range of tensions with local communities, including the negative impact of telecommunications restrictions, negative impacts on local agricultural economies, and perceptions of inadequate communication and engagement. In the Special Issue, six articles focussed on SKA host communities. Broadly, this presents an extension of a discourse that originally emerged from Hawai'i and Latin America into an African context, focussing on host community contestation against scientific institutions. However, the approach in the special issue is multidisciplinary, examining the colonial history of astronomy in South Africa (Dubow 2018), the interplay between indigenous identities and astronomical infrastructures (Parkington et al. 2019), political contestation of land and identity (Chinigò 2019), and the competing concepts of 'development' held by scientific institutions and host communities, respectively (Atkinson 2019; Gastrow and Oppelt 2019). A critical approach is taken by Walker (2019), using the anchoring concepts of 'place' and 'space', and drawing on critical cosmopolitanism as a theoretical framework: 'The promotion of astronomy in the Karoo is premised on a metropolitan view of this region as politically and economically marginal: effectively empty space, to be put to good use in the service of global science and national development, rather than a deeply historical place, long embedded in trans-local dynamics and facing significant, largely unresolved social challenges today' (Walker 2019: 1).

Following on from these contextualised analyses, the third periodisation is characterised by reflective conceptual work published in 2020 and 2021. This set of articles is more diverse, both in terms of their journal and their focus. Pertuze and Pfotenhauer (2020), publishing in *Research Policy*, reflect on learning and capacity building within the Chilean astronomy cluster. The remaining two papers are published in lower-impact journals but nonetheless present evolutions in the discourse. Sammler and Lynch (2021) take an explicitly postcolonial view of astronomy in Hawai'i, while Leheudé (2022) takes a political view of data infrastructure.

The broad arc represented by the periodisation described above is structured by an initial reaction to the controversy of the Thirty Metre Telescope, in conjunction with critique emerging from Chile, which informed later cognate research in South Africa, as well as ongoing, diverse, critical and conceptual research. In common, amongst these disparate but connected literatures, is critique of the power dynamics that underpin the development of astronomy facilities in the Global South, and in particular the interplay between internationalised scientific institutions, and local cultures, histories, and economic interests. There are, however, distinct narratives emerging from different disciplines and journals. Articles in *Nature* and *Minerva*, two established publications of the scientific community, largely aim to present a balanced narrative that takes into account perspectives from both the institutions of science and local host communities. On the other hand, articles from the anthropology-based *Journal of Southern African Studies*, as well as *Tapuya-Latin American Science Technology and Society*, generally offer a more critical approach that focusses on the uneven power dynamics observed between astronomy facilities and their host communities.

Discussion

Development and Dependency

Nearly half of the articles that focus on host communities in the South discuss concepts of "development". The discourse commonly includes reflections on the ways that astronomical sites are accompanied by promises of economic, social, and educational progress, as well as promises of modernisation for the host region or, more often, the host nation of astronomy facilities. Within this overarching discourse, there are distinct approaches towards how the delivery of such promises is evaluated.

One approach focusses on the national level. Articles here argue that astronomy and the development of astronomy observatories have spillovers – "the effects of an activity that have spread further than was originally intended" (Guridi et al. 2020). Spillovers can be positive or negative but are more commonly conceptualised as positive, being identified as opportunities for technological transfer, professionalisation and education, and growth of social capital. Hannah Dalgleish, for example, argues that "astronomy is a wonderful tool for development" in South Africa, noting that education programmes are necessary to support the development of astronomy facilities for employees that will support the observatory's operations (Dalgleish 2020). Similarly, Guridi and co-authors point to knowledge spillovers in Chile with the growth of astronomy programmes due to the development of astronomy clusters in the country as well as collaborations between astronomy facilities like the Atacama Large Millimetre Array and technical universities that train students for the specific needs of the observatory. These authors further identified knowledge spillovers occurring due to lateral employment moves by highly trained observatory employees who "left observatories to join other industries", particularly in the fields of software development and project management. However, where these individuals then relocated (if, for example, they remained near the observatories in

the Atacama region or moved to significantly larger urban centres, such as Santiago de Chile) is not discussed, meaning we have a limited understanding of how these knowledge transfers are distributed. Guridi and co-authors identified infrastructural and industrial spillovers for the host nation, such as the extension of fibre optic networks. They also noted the development of partner industries to observatories, consisting primarily of operational and maintenance services such as food services, maintenance services, and even astro-tourism in the region of large observatories. However, discourses about the benefits of astronomy also acknowledge reservations about the unequal distribution of said benefits, particularly at the local level. For example, creating labour inequalities between skilled and unskilled workers, and the top-down nature of these benefits, which mostly accrue at the national level rather than by the locality itself, are of particular concern (Guridi et al. 2020).

A more critical approach is adopted in other articles. Atkinson (2019) argues that support for astronomy facilities predicated on their developmental power is too often part of top-down, centralised and - even more strongly put - "quasi-authoritarian" programmes. Gastrow and Oppelt (2019) and Walker (2019) illustrate ways in which the development of astronomy infrastructures has not included adequate participation by local host communities. Such critical discourses, focussing on the localities of infrastructures, have largely emerged from the case of the Square Kilometre Array—a territory that itself has a multifaceted history deeply entwined with colonialism and Apartheid. Articles that have focussed on Chilean cases, from the ALMA to the Atacama Astronomy Park to Chile's longer transnational history of astronomy, have identified similar dynamics. Guridi et al. (2020) articulate how facilities will "likely effect the lives of local communities". While their article claims that the development of the Atacama astronomy cluster "sparked considerable local controversy and legal action", it does not discuss what form these controversies took. On the other hand, Lehuedé (2022) describes how communities affected by the ALMA consider these astronomy infrastructures to be "the start of a new chapter in their history of territorial struggle" (Lehuedé 2022: 3). Taken together, these articles offer a strong critique of splintered scales of interest: the macro/national and the micro/local, in which the well-being of the latter is seen to be subservient to the development of the former.

In addition to the national and the local, a third discourse focusses on the international, within which critiques of developmentalism expand upon questions of *dependency*. Development at the national level is related to questions of geopolitics, particularly in mega astronomy projects sited in the Global South that are often (if not exclusively) funded by institutions of the Global North. Both the ALMA and the SKA are the result of large international collaborations with multiple participating partners, the majority of which are developed Western nations. In this light, both Javiera Barandiaran and Saul Dubow lean on longer histories than the development of a single facility (Barandiaran 2015; Dubow 2018). Both authors, writing about different contexts (the former in Chile, the latter in South Africa), point to ways in which the history of astronomy in these respective contexts is rooted in a history of North-South dependency. Barandiaran draws on Latin American *dependency theory,* which points to the neo-colonial relationship between the *centres* of the world (wealthy states) and the *peripheries* of the world (developing countries—see,

for example, Marini 1973; Cardoso 1993). She shows the resilience of hierarchies of dependency in Chilean astronomy, arguing that even though astronomy as a field and access to instruments have grown in Chile in the past forty years, so has the nation's dependency on foreign investment. This results in the South remaining dependent on expertise and technology that is imported from the North, never—or rarely—truly developing the means to do it on their own terms. Similarly, Dubow examines the history of South African astronomy, showing how its development was largely shaped by Britain and British scientists, followed by an Apartheid era effort to nationalise astronomy so as to advance national prestige. He argues that, as a result, much of South African astronomy is still shaped by histories of segregation and the continuous dependency on foreign investment.

Across these various discourses, there is broad agreement that promises of development emerging from astronomy infrastructures privilege the national and international contexts, and that the participation of and impact on local host communities have been marginalised by this logic. A critical body of work argues that big astronomy projects reproduce asymmetrical and hierarchical power relations between national and local interests, and between the Global North and South through fostering dependency in the Global South on technology and expertise from the North.

The recommendations emerging from the literature address this issue. Although many of the papers have a theoretical or analytical focus and do not put forward distinct recommendations, those that highlight specific recommendations commonly focus on measures to make astronomy more equitable and developmental. Recommendations range from having a specific focus on a particular community, through to the national and international arenas. At the local level, Alegado (2019) addresses the Mauna Kea controversy, suggesting that all construction of the TMT be paused in favour of renegotiations between community, the government and the University of Hawai'i, and that the environmental damage caused by the thirteen other telescopes on Mauna Kea be reversed as a symbol of good faith between community, university and state. Other recommendations are directly towards the role of the state: Dalgleish (2020) recommends that the astronomy sector develop sustainability standards to guide infrastructure development globally, highlighting that astronomy is a "wonderful tool for development", while Atkinson (2019) stresses the need for greater co-ordination across different levels of government as critical to meaningful engagement between local host communities and international astronomy facilities. Guridi et al. (2020) recommend strong domestic policies are needed to guide spillovers from astronomy investments. Governments should therefore adopt a dynamic perspective to capitalise on spillover opportunities. Most knowledge spillovers are at the beginning of development, which means this should be understood from the outset for host countries to be engaged in this stage of infrastructural work. Related to this, Gastrow and Oppelt (2019) recommend that developing a meaningful and empirically informed understanding of the social dynamics of host communities is a strategic imperative for large scale science facilities—and that both the state and the institutions of science require social research from the earliest stages of infrastructure development.

Space and Place

Cherryl Walker (2019) articulates and uses concepts of 'space' and 'place' to assist in understanding different conceptualisations of a locale—in which rich social 'places', with their own histories and social lives, are sanitised and transformed into empty 'spaces' that serve the needs of a scientific community. Similar themes emerge in other articles, with foci on the relationships between local communities, their identities, and their relationships to the land on which astronomical sites have been built—while showing how little of these social lives are taken into consideration within the context of astronomy facilities and those who advocate for them.

Cognate with this conceptual distinction is the analysis of ways in which indigenous communities of a locality understand their personal relationship to the land they reside in, and how changes that occur on this landscape affect them and their social identity. In the context of the SKA, articles by Davide Chinigò as well as John Parkington and co-authors tell a history of the upper Karoo and the indigenous peoples who are "not only *in* [these] places but *of* them". They discuss the relation of these indigenous groups and peoples to and with the land, and how changes to this environment over time—primarily through the intervention of colonialization—affected and were affected by these people and groups. Chinigò traces a long history, showing transitions of the economy in the Karoo region from the commercial farming revolution to the new "astronomical revolution" marked by the development of the SKA infrastructure. Parkington and co-authors show how indigenous "Karoo dwellers" come from various groups, identities, and communities. They argue that newer Kalahari groups have taken on the role of speaking for a wide range of Karoo communities, including populations that have repeatedly been displaced and disenfranchised over the past two centuries but are not representative of these displaced Karoo communities. Ultimately, both articles point to how economic and land development brought in by astronomy facilities often enhance historical debates among and between populations—of the past and present. This is particularly true in the context of the Karoo, where land disputes and displacements have been ongoing for centuries (Chinigò 2019). Correspondingly, in the case of the Atacama in Chile there is analysis of tensions between mining communities and the astronomy community (Guridi et al. 2020), as well as historical tensions between mining communities and the Atacameño indigenous groups about questions of land ownership, extractivism, and tourism.

There is a convergence among scholars in asserting that facilities are developed along entrenched divergent understandings and articulations of the land the facility is built on: resource and landscape for those who seek to develop it, or home and hearth for those who reside there (and have long resided there). Among the key articulators of this bifurcated conceptualisation of the locale is Cherryl Walker, who discusses how the marginalised history of the Karoo (South Africa) renders it a suitable site for development driven by national and Global North interests, leading to an uneven encounter between the local and the global (Walker 2019). In this context, the Karoo is articulated by advocates of the SKA as a series of conditions (it has "'high atmospheric transparency, low levels of light pollution, low population

density or minimal radio frequency interference"', according to a South African governmental *Gazette*, quoted by Walker 2019, p. 658). These conditions, ultimately ones that leverage the alleged sparsity of the space, can thus be harnessed. The qualities and values of the local community and other stakeholders are thus *emptied from* the place to create a space to which fraught questions, including those regarding ancestral stewardship of the land, no longer belong.

Analogous arguments have emerged in the cases of Hawai'i and Chile. Katherine G. Sammler and Casey R. Lynch write about two new space science infrastructures, the Thirty Meter Telescope on Mauna Kea and the Hawai'i Space Exploration Analog and Simulation (HI-SEAS) on Mauna Loa. In their work, the authors account for the apparatuses and material practices that underpin the work of observation. They note how the narrative of astronomy is one that is often predicated on its entanglements with passivity, universality, and neutrality. It cannot do harm because it is a science based on observation, and observation is a non-active action. This narrative, however, eludes the positionality of the subject that does the observing—where they are located, where their observatories are built—and, indeed, the very material reality of the process of observing. In their words, "the contingencies of the colonial context constantly threaten to undermine this 'view-from-nowhere' logic" (Sammler & Lynch 2021).

This narrative, in turn, has become the focus of critique within much of the literature addressing host communities, which centres, or at least surfaces, the experience and agency of host communities, and frames the work of astronomy as action in and acting upon the world. The reality of settler colonial contexts—the points of view of non-scientists, of local communities—in offering differing articulations and understandings of the locale, clashes with the idea of emptiness that astronomy needs to articulate to build its infrastructures. A similar argument emerges from Sebastián Lehuedé's fieldwork near and at the ALMA. Lehuedé traces "ontological divergences" in conceptualisations of territory and land that were at the root of conflicts that emerged during the expansion of the infrastructures for the ALMA (Lehuedé, 2022). In a striking illustration, Lehuedé traces a conflict between the community of Toconao and the ALMA when the ALMA were building natural gas pipelines. Though initially ALMA consultants did not see any adverse effects of this pipeline, members of the Lickan Antay community were aware of colonies of *chululos* (small rodents) that lived on the site. To them, destroying these colonies would amount to potentially breaking the entire ecosystem due to Lickan Antay ontology of *Pachamama* (Earth mother) and the interconnectedness of the system. Here, again, we see divergent constructions of the territory: the emptiness of the land, perceived by consultants, did not account for the creatures that the *Pachamama* ontology demands accounting for. It seems that astronomy's powerful ability to account for the fullness of the skies does not extend to an account of the fullness of our Earth-bound places.

The emerging challenges to discourses that frame astronomy as a 'non-action' in the terrestrial sphere find parallels in science policy, particularly with respect to an increasing focus on 'astronomy for development'. The International Astronomical Union established its Office of Astronomy for Development in 2011, which coordinates a wide range of development projects amongst communities associated

with astronomy infrastructures. This shift occurred due to growing recognition that local communities are significant stakeholders for such infrastructure, and that constructive relations with host communities are beneficial both for astronomy and for society. However, tensions between the institutions of astronomy and host communities remain, as evidenced by community protests in Hawai'i, Chile and South Africa subsequent to 2011. While institutional support for development projects marks a step forward with respect to the relationship between astronomy and community, the cultural and political challenges that characterise situations where the interests of astronomy diverge from local interests require more than development interventions. They require foresight, cultural knowledge, and meaningful negotiation if they are to avoid the precise pitfalls that are also discussed in this scholarship regarding development and dependency (see previous section).

Conclusion

Literature addressing the social and policy aspects of astronomy facilities has an emphasis on the Global North. However, literature addressing host communities has an emphasis on the Global South. Broadly, the discourses related to host communities in the Global South have emerged from reflections on the controversies related to large-scale telescopes in Hawai'i, Chile, and South Africa.

Against a background of discourses that frame the impact of astronomy in the Global South as essentially positive at the national level, several critical discourses have emerged in the past decade to challenge the institutions of astronomy. One common theme linking among these discourses is that a focus on benefits at the national and international levels obscures a range of problematic power dynamics and outcomes at the local level. The notion of the Global South, and especially host sites, as an 'empty space' in which astronomical observation does not constitute impactful action amongst local communities, is challenged by discourses that centre local contexts, and challenged by discourses that employ conceptual frameworks with a focus on revealing power dynamics.

The literature reveals different conceptualisations between the developers of astronomy infrastructures and those who tend to and live in the locality that surrounds them. This ontological divergence is often one aligned with North-South distinctions, settler colonial histories, and of racial formations. Thus, categories like North-South as well as centre-periphery crystallise key ontological differences, and demarcate these differences as not solely relegated to geopolitical tensions. Instead, North-South categories bring back these differences to questions of *power* and *domination*, showing how rationales of objectivity, neutrality, and "the-view-from-nowhere" are pushed upon *emptied* spaces—spaces that ought, instead, to be understood as rich, diverse social places whose communities carry their own visions for what that locality should look like.

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