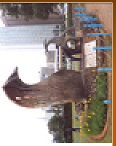

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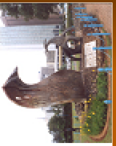
Kenya International Radio Observatory (KIRO)

Joseph Otieno Malo, University of Nairobi, Kenya

Bo Thide, Uppsala University, Sweden



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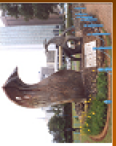
ABSTRACT

- This paper proposes the building of a new type of versatile, multi-purpose, world-class radio facility space, environmental, and communications research.

- Located in northern Kenya, on the geomagnetic equator, the Kenya International Radio Observatory, KIRO will be a world-class, multi-purpose radio facility designed foremost for the study of the terrestrial magnetosphere, ionosphere and neutral atmosphere using traditional as well as newly developed diagnostic techniques.



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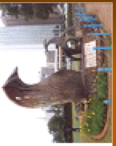
- With its flexible modular design, KIRO will be ideally suited for studies of the fundamental physical and chemical processes in the upper atmosphere, the ionosphere and the magnetosphere which have a decisive influence on life on Earth.

- With KIRO it will also be possible to make unprecedented studies of the Sun, Moon, the planets, the interplanetary plasma and galactic and extragalactic radio sources.

- Finally, KIRO will be an excellent facility for application of modern electronics and communications technologies.



I: INTRODUCTION

Back in 1980s a group of Indian, Kenyan and Nigerian scientists developed a proposal to establish an International Institute for Space Sciences and Electronics (INISSE) and the construction of Giant Equatorial Radio Telescope (GERT) at site close to the earth’s equator.

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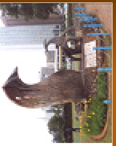

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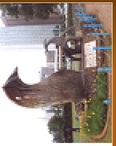
- The development of indigenous scientific and technical skills and their utililzation for satisfying the social and economic needs of the people are a great challenge for the developing countries.

- The demands of the people in the modern world are complex, seeking not only progress in areas such as agriculture, medicine and education but also in the fields of energy generation, rapid communications and general industrial development.



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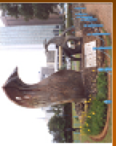
- Apart from the need of developing and advancing indigenous technological efforts, it seems desirable to undertake regional and inter-regional cooperation in as many areas as are considered practical with the aim of not only undertaking relevant task-oriented projects but also building up local scientific and technological self-reliance and capabilities.



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- It is proposed that an International Institute of Space Sciences and Electronics (INISSE), which will develop its programmes around one area of basic sciences and one related area of applied research, be formed as a joint effort of a number of developing countries.

- The two chosen areas are: Radio Astronomy and Space Applications Technology.

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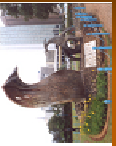
- Mainly, the areas chosen are those which seem highly relevant, will act as an excellent catalyst for collaboration amongst the developing countries in terms of technology development in the different areas of space applications technology and electronics, and yet are practical, and not too costly, to realize with indigenous efforts.



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II: SCIENTIFIC PROGRAMMES (INISSE/GERT)

- The ability to cover major parts of both the northern and southern hemisphere of the sky will be a unique feature of this observatory and of tremendous scientific value.
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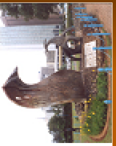
- The proposed site of the project through which equator passes is relatively inaccessible and remote and therefore free from the electromagnetic radiation from broadcast, TV utilities and radar stations developed on the ground.



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II. 1: Lunar Occultations

- Is to make details study of hundreds of radio galaxies and quasars by utilizing the method of Lunar Occultations to obtain high angular resolutions for studying small scale structures of radio sources and determining their position and angular sizes and intensity of signals (which is a measure of energy) emitted by the source.
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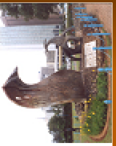
- In these technique the moon is used as a screen and physical phenomena known as "Diffraction at a straight edge" is observed.



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- These studies should provide very valuable information about the origin, evolution and energetic of powerful radio sources that are not well understood today.
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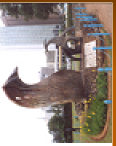
- The results obtained from these observations are of immense value for Cosmological investigations and study of the Physics of radio sources. The results are also vital for determining which of the two models – the Steady State or the Evolutionary – best fits observations.

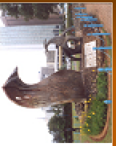


II. 2: Interplanetary Scintillations

The phenomenon of interplanetary scintillation enables detection of very compact radio sources of angular sizes less than one second arc.

Strong scintillation which are actually fluctuations in the intensity of the radio signals from compact sources are observed when angular separation of the radio sources from the Sun is small (few degrees to a few tens of degrees).

The fluctuations are caused by irregularities in the density of the electrons in the interplanetary medium.



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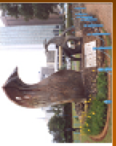
- Studies of these scintillations help in the dermination of the angular sizes of compact radio sources as well as the characteristic of the interplanetary medium.
-
- The angular sizes of compact radio sources and the proportion of intensity of the radio signal contributed by them are valuable for cosmological investigations. Regular monitoring of the interplanetary scintillation of radio sources will help as one of the best early warning systems for geomagnetic disturbances which cause disruption in radio communications.



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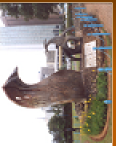
III.3: Pulsars

- Pulsars are very exotic celestial objects first discovered accidentally at Cambridge, England during routine interplanetary scintillation observations. These objects are now associated with Neutron Stars the existence of which was theoretically predicted in the 1930s.
-
- The observatory could also be used for discovery of pulsars as well as the characteristics of the pulsars and of the interplanetary medium. Further the observatory could be used for other programmes such as flare stars, radio-recombination line, deuterium line studies near galaxies and Clusters of galaxies etc.



III: KENYA INTERNATIONAL RADIO OBSERVATORY

- The aim of the space sciences is to explore and understand the large scale environment of the Earth with its natural and man-made variations.
- This encompasses studies of processes in regions ranging from the surface of the Sun and the planets, through the solar and interplanetary plasma, to the magnetosphere, ionosphere and neutral atmosphere enveloping the Earth.

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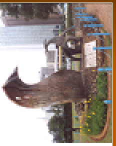
- To study the fundamental physical principles governing the solar-terrestrial environment, powerful scientific instruments are required.

- Satellite observations can only provide a limited set of local snapshots from this environment and must be complemented by observations of processes taking place on large spatial scales and over extended time periods.

- Furthermore, many regions of solar-terrestrial space can only be probed by instruments sensing the processes remotely.



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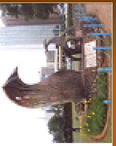
- We propose here the construction of Kenya International Radio Observatory, KIRO, a judiciously designed radio facility, versatile and flexible enough to allow the study of a large variety of physical phenomena in virtually all space regions of interest, from the Earth's neutral atmosphere to the Sun and beyond, with one and the same instrument.



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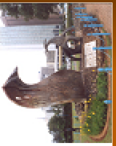
- Realizing that it would be difficult to motivate scientifically, politically, and indeed financially the construction of a relatively costly, specialized, essentially single-purpose large research instrument, the multi-purpose facility described here, the KIRO, would be a world-class radio observatory of a new kind, open to the entire international scientific community for use in ground –based space physics, astrophysics and environmental research well into the new millennium



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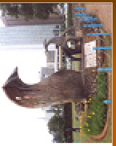
- The KIRO is proposed to be located at the geomagnetic equator, in northern Kenya, and be designed and built through a multinational collaborative effort.

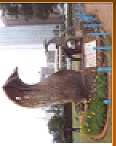
- The KIRO will be designed to utilize a combination of modern methods, techniques and technologies which is not yet available at any other facility.



Thus KIRO will address and resolve such important questions as:

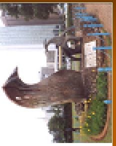
- How do the large variations in the Sun ‘s activity, mediated to the Earth via the natural solar wind, affect the state of the ionosphere and /or the upper atmosphere?

- How can we understand the mechanisms responsible for the generation of the copious amounts of natural electromagnetic radiation in the Earth’s magnetosphere that continuously ‘bombard’ the ionosphere and have done so for eons?

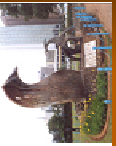


- Can we learn anything from electromagnetic radiation observed in our own space habitat? Can we apply such knowledge to help interpret the physical processes that generate the electromagnetic radiation received from remote sources such as radio astronomical objects? If so, does this radiation contain any signatures which can help us understand the creation and the development of Universe and our own planet?

- Have the natural physical processes that take place in the Earth's magnetosphere and ionosphere, located at hundreds to thousands of Kilometre altitude, any measurable connection with processes in the atmosphere at much lower altitudes, or perhaps even on the Earth's weather system and climate?



- Does the electromagnetic radiation from the tens of thousand of broadcast, TV utility and radar station deployed on the ground by man over the past century have any effect on the ionospheres? If so, is this an adverse or a positive effect? Or, if measurable at all, is it negligible?
- Compared to the ionosphere over densely populated and heavily industrialized regions, the equatorial ionosphere is a pristine part of the Earth’s near plasma well suited for comparative studies of such effects.



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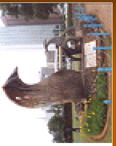
This will be possible at KIRO since this facility would allow:

- PERFORMING GROUND-BASED RADIO AND RADAR STUDY OF SPACE SURROUNDING EARTH much further out much on much larger spatial scales than with any other existing ground-based instrument.
-
- One aim is to investigated the plasma processes which give rise to natural waves, turbulence, non-linear structures and chaos, which we have only limited knowledge of today, but which in a decisive way influence the atmosphere and near space, and hence conditions for life on Earth.



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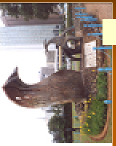
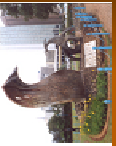
- **DEVELOPING AND UTILIZING NEW EXPERIMENTAL TECHNIQUES**, based on modern linear and non-linear physics and technology, for high-precision studies of both natural, spontaneous processes, as well as systematic phenomena created under both controlled and reproducible conditions, analogous to the way physical phenomena are studied in earth-bound laboratories.



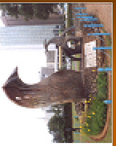
- STUDYING THE DYNAMIC OF THE EARTH'S ATMOSPHERE over a very large range of spatial scales by the well-known 'weather radar' method, which utilizes the scattering of radio waves from weak natural fluctuations in the atmospheric refractive index.
-
- Long-term investigations of this kind will lead to an improved understanding of the climatology of the equatorial troposphere, mesosphere and stratosphere and will contribute to the establishment of a reliable database of continuous series of observations.
- Such databases will be invaluable in the future for all areas of the atmospheric sciences.



- PERFORMING SOLAR, LUNAR, PLANETARY AND ASTROPHYSICAL RADIO OBSERVATIONS from equatorial latitudes under favourable geophysical and technological conditions.

- DETECTING ELECTROMAGNETIC RADIATION WITH NEW METHODS which enable us to determine, to a very good precision and with a high dynamic range, all characteristics (amplitude, phase, spectral content, direction of arrival, and state of polarization) of the signal received.

- These methods are expected to be of major future importance in physics, astronomy, medicine and industry.



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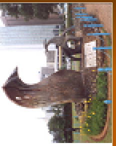
The KIRO design comprise:

- An easily expandable modular construction, allowing the possibility of starting on a moderate scale and expanding the capabilities as new funding and technology become available

- A wide range of frequencies, lower than that of most existing ionosphere radars and higher than that of any existing ionospheric HF facility, thus covering a largely unexplored intermediate range of the frequency band

- A newly developed array “information dense” antenna system, usable over a wide range angular and frequency range.
- Front-line digital and analogue radio technologies and data systems for handling large quantities of data, including a distributed data taking system allowing after the fact adjustment of experimental parameters.



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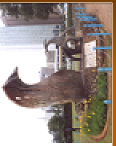
- By choosing a straightforward and simple modular design and using commercially available standard products wherever possible, the investment and recurrent costs will be at a reasonable level.
-
- With this design philosophy, it should be possible to build a first, entry version of KIRO, capable of performing substantially new experiments for about US$ 10,000,000, whereas the total investment cost for the full-fledged KIRO can be estimated at US$ 30,000,000



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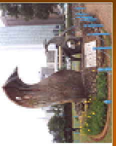
- This must be considered quite modest, considering the multi-purpose capabilities of the facility and its potential to probe regions from the lowest atmosphere to the high-altitude magnetosphere, while at the same time being an excellent instrument for studying atmospheric chemistry, astrophysics and fundamental space plasma physics.



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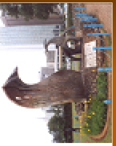
IV: DISCUSSION AND JUSTIFICATION

- It is well known that many of the sophisticated techniques and instruments developed for radio astronomy such as a large antennae systems, low noise receivers and optimum methods in data processing and image reconstruction have found applications in many areas such a radars, microwave and space communication and even the mapping of brain and body tumors.



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- It thus seems clear that a highly challenging and well-identified scientific project such as KIRO could provide an excellent focusing point and act as a good catalyst for international collaboration in the field of radio science and electronics.

- We therefore propose the establishment of an institute (INISSE) which will undertake simultaneously both the construction of the proposed Radio Observatory and the design and development work in certain fields of microwave communications and electronics that is of immediate relevance to the participating countries