ROUGH DRAFT April 5, 1949

N. Nicolet
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Dear Monsieur Nicolet:

In regard to the experiments upon the subject of radio astronomy: these may be divided into two parts, the first relating to the sun and the second relating to the Milkway. This division may be made partly on the basis of equipment and partly on the basis of the intensity frequency relations. For solar work, it is highly desirable that the radio wave collecter be mounted upon a polar axis so that the machine may properly follow the sun from rising to setting. In general, the solar intensity is a direct function of frequency and consequently these studies are more readily performed at short wave lengths. The surface brightness of the sky in the region of the ~~Milkway~~ Milkyway is an inverse function of frequency and consequently the study may be more readily made at longer wavelengths. In the region from one half to five meters the two sources of radio waves ~~of~~ are comparable intensity and may be detected by equivalent machines.

In this country, there are several mirrors 25 feet in diameter and one 32 ~~feet~~ feet in diameter now operating. Two 50 foot mirrors are under construction. Most of these machines will be used to make solar investigations. All of ~~these~~ machines are large and heavy and require substantial ~~outlines~~ outlays in engineering, ~~and~~ equipment and money.

Unless some equivalent is available for use by Irsac, it seems likely that possible radio astronomy studies by this organization should be in a field of different activity than is presently being covered in this country. Various experimenters have made constant intensity contours of the radio waves arriving from the Milkway at frequencies from 64 to 480 Mcs. These contours demonstrate that the phenomena is similar but the details are substantially different on these different frequencies; thus it may be concluded that we are viewing the galaxy in different manners and quite likely at different distances. Other experimenters have demonstrated that certain places in the sky contain radio frequency sources of high intensity and of very small diameter. These studies are important in relation to astrophysics and in a determination of the background radio noise levels likely to be encountered at a given receiving station. These background levels will be different at different wavelengths, with different antennas, at different times of day and at different seasons of the year, however the phenomena is believed to be of continuous and steady nature and consequently it should be possible to predict what noise background will be encountered under any of the above conditions if sufficient data is available to make an accurate prediction.

The location of IRSAC near the equator of the earth is very advantageous for making surveys of the galactic radio waves in that all the sky may be surveyed from a given location. It is thus suggested that an important contribution could be made by your organization along these lines.

From an astrophysical point of view, the most important parameter desired is that of direction and the second most important is that of intensity. In other words, the first wish is to know accurately the direction of arrival of these galactic radio waves and the second is to know their intensity. Thus some type of collector system must be devised which can be steered from one place in the sky to another. Furthermore the resolution should be as large as possible so that one direction may be accurately singled out from all others. These requirements are most readily met in the microwave region where mirrors of reasonable size are readily mounted to be pointed in any desired direction. Unfortunately, the intensity of galactic radio waves is far below that measurable by the best electronic equipment in the microwave region. The region from 1/2 meter to 5 meters has reasonably well been covered as outlined above, thus further experiments should be made in the long-wave region; that is at frequencies below 30 Mcs.

Since the requirements for resolving power are just as demanding in this region it is obvious that some type of collector other than a mechanically moveable mirror will have to be devised. Furthermore there will be a lower limit to the frequency at which a suitable experiment may be performed due to the absorption and shielding of the ionosphere. We are now on the down part of a sunspot cycle and consequently the critical frequencies will be progressively becoming lower. From this, it seems that the next few years before the rise of the next cycle begins will be a good time to perform galactic radio waves at as low a frequency as possible.

Various considerations indicate that a frequency of 10 Mc will be suitable for these measurements and will only be [redacted] interrupted during the day for a few days throughout the year within the next few years.

In scanning the sky, eastwest motion may be securred by the rotation of the earth, thus the collector need only be steered in a northsouth direction. On any given day, the collector may be pointed at some given declination and intensity [redacted] versus time (right accession) may be measured. Other days different declinations may be used and over a period of time the entire sky may be covered. At true noon, it will be possible to make a measurement of solar intensity in the same fashion as a transit telescope is used.

One suitable type of collector will consist of a large [redacted] array of dipoles. Numerous dipoles (10 or 12) may be mounted co-linearly in an eastwest direction. The resolved power in right accession of the collector will [redacted] depend upon the number of dipoles used in the eastwest direction. The collector will be composed of a large number (20 or 24) of these lines [redacted] all placed parallel in a north-south direction. Resolving power of the collector in declination will depend upon the number of lines used. Theacceptance pattern of this collector will be vertical when all elements in each line [redacted] and all lines are in phase. Each element in a given line will at all times be maintained in [redacted] phase. The [redacted] acceptance pattern may be steered in a north-south direction by advancing or retarding the relative phase between ~~sufficient~~ successive lines. If phase is altered by 5°, the axis of the pattern will be swung in an opposite direction by 10°, thus to steer the pattern plus or minus 30° from the vertical requires that electronic means be provided to adjust the phase between successive lines plus or minus 40°. This steering may be best accomplished when there are a large number of lines in the array because under these circumstances the pattern will not tend to break up as rapidly as when there are only a few lines, or when groups of lines are held in phase and the various groups phased one to another. In any case, such a collector while large will be a relatively simple and cheap devise to construct. No extensive engineering nor accurate machine work nor heavy equipment nor expensive parts are necessary. It will be merely sufficient to find a flat piece of ground of such size and plant therein a large number of poles. Estimates for an area for the resolving power of 5° in declination and 7° in right accession are as follows. Assume 18 co-linear elements in each line and 24 lines at a frequency of 10 Mc. This will require 456 poles each 30 feet long to support the elements and approximately 138 poles each 8 feet long to support the feed lines. 864 small insulators will be needed to support the elements from the large poles and approximately 2446 insulators will be needed for the Franklin stubs and 542 insulators for the phasers. 21,600 feet of wire will be needed for the elements, 2,400 feet for the Franklin stubs and 6,090 feet for the phasers making a total of 48,900 feet of wire or approximately 10 miles. This wire may be of light gage such as 14 or 12 hard copper or copper-weld steel. The insulators may be a cheap glass or porcelain receiving type. The poles may be anything which the surrounding forests make available. The area of the collector will be 900 feet by 1150 feet and the area of the land cleared 1200 by 1500 feet giving about 150 feet clear around all sides of the collector. Since the elements will be 25 feet above ground and the phasers approximately 5 feet above ground the above pole lengths are adequate for any usual soil conditions. The ground should be flat to within plus or minus 3 feet over the above area.

An outlay as described above may sound very ambitious at first. However some consideration willshow the major part of the work, to be securing the poles, digging the holes and stringing the wire. These may be performed by quite unskilled labor. The most skilled part will be involved in lining up the elements. Once a single line has been put into operation, the others will readily follow. Adjustments between the lines may be readily made by means of the phasers. Once secured, a sample scale mounted between the poles will allow any desired adjustment to be returned to.

As outlined above, it is believed that an installation of the type described would produce astronomical data of considerable importance and it seems likely that this large antenna would find many other uses for ionospheric research once the original services for which it was constructed had been completed.

It is believed that our organization will be in a position to actively cooperate with Irsac upon the construction and operation of such a combined adventure. As an estimate, we will supply wire and electronic receiving equipment along with portable power supplies. Irsac is to supply a suitable piece of land near civilization, provide housing facilities for personnel, supply unskilled labor for clearing the land, secure the poles, make a survey, to lay out the poles and plant the poles and string the wire. We will supply the services of the one or possibly two engineers to make the installation operate in the desired fashion and take the data for our galactic survey.

For design considerations see Proc. IRE, Sept 1930, Fig 15, p 1518 and 1519

An initial estimate indicates that approximately 6 months should be required to construct the installation and another year will be required to put it into operation and make the galactic survey. After this is done, the installation is [redacted] to remain at Irsac and may be used for other purposes by other people. We hope that this matter will be given thorough consideration by your organization and that some [redacted] plan along the lines described above may be worked out for the mutual benefit of both our organisations.