

## SEARCH FOR NEUTRAL HYDROGEN IN THE EARLY UNIVERSE

I.F. Mirabel

Departamento de Física  
Facultad de Ciencias Naturales  
Universidad de Puerto Rico

## RESUMEN

Se da un informe sobre las búsquedas de emisión de hidrógeno neutro en épocas tempranas del Universo.

## ABSTRACT

A report on the progress of searches for neutral hydrogen emission in the early Universe is given.

**Key words:** GALAXIES-FORMATION – GALAXIES-INTERGALACTIC MEDIUM – COSMOLOGY

Our understanding of the birth of galaxies and clusters of galaxies is far from being clear and observational approaches to this problem are of outmost importance for determining the parameters of the process. A radio-astronomical approach to the detection of early condensations of matter as it passed through a neutral hydrogen phase has been proposed by Sunyaev and Zeldovich (1972, 1975), who suggested that a large fraction of the mass in protoclusters of galaxies ( $10^{14}$ - $10^{15}$  solar masses) would be neutral hydrogen at temperatures less than  $10^4$  °K. Such massive neutral clouds should be detectable as redshifted 21 cm line emission.

A first search for such emission in selected areas of the sky at 328 MHz ( $z = 3.33$ ) and 240 MHz ( $z = 4.92$ ) was carried out with the 250 foot fully steerable radiotelescope at Jodrell Bank by Davies, Pedlar and Mirabel (1978).

During 1979, Mirabel, Jackson and Bonnell continued this search surveying the north celestial polar cap with the 300 foot radiotelescope of the NRAO<sup>1</sup>. Two 2.5 MHz bandwidths centered at 141.40 ( $z = 9.04$ ) and 201.25 MHz ( $z = 6.06$ ) were surveyed. The performance of the receiver was monitored by observing hydrogen recombination lines at the frequencies used for the protocluster search. The observations at  $z = 3.33, 4.92$  and  $9.04$  show that either the number of protoclusters containing substantial amounts of neutral hydrogen in the early Universe is less than  $10^6$  or that their masses are less than  $3 \times 10^{15}$  solar masses. The analysis of the observations at  $z = 6.06$  is in progress.

During 1980, Mirabel and Altschuler have continued the search for primordial protoclusters of galaxies using

the 430 MHz ( $z = 2.30$ ) receiver and the 1000 foot radiotelescope of the Arecibo Observatory<sup>2</sup>. At 430 MHz the predicted HI emission temperatures are of  $0.2^\circ$ - $0.4^\circ$  K allowing for beam dilution. The likelihood of having a protocluster within a random region of the sky with the same size as the telescope beam is smaller than  $3 \times 10^{-2}$ .

Quasars are the objects more likely to supply fairly direct evidence about the early stages in the evolution of concentrations of matter and there are several reasons to believe that the more massive primeval galaxies in protoclusters have been identified as QSOs. We have carried out a search for neutral hydrogen emission in the direction of ten QSOs at  $z = 2.30$  using a 10 MHz bandwidth. The data taking was successful and the analysis is being carried out at the moment.

No protocluster of protogalaxy has been detected so far. Our observations demonstrate that it is feasible to make an adequately sensitive search for the redshifted neutral hydrogen emission from protoclusters of galaxies. Positive results would provide information on the epoch of formation of galaxies and properties of protoclusters. Negative results may be used to set limits on the mass and number of such objects.

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## REFERENCES

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2. The Arecibo Observatory is part of the NAIC, which is operated by Cornell University under contract with NSF.

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Igor Félix Mirabel: Departamento de Física, Facultad de Ciencias Naturales, Universidad de Puerto Rico, Río Piedras, Puerto Rico 00931.

