HALCA Images of The Young Radio Source 1413+135

G. Langston, A. H. Minter, F. Ghigo

National Radio Astronomy Observatory, Green Bank, West Virginia 24944, USA

ABSTRACT

The radio source 1413+135 is remarkable for a number of reasons; 1) it is 18 times more variable at 8 GHz cm wavelengths than at 2.3 GHz, 2) it is one of the few (~ 4) sources where radio absorption lines of H_I, CO, HCN and other molecules (Wiklind and Combes 1994 A&A **286**:L9) have been detected, and 3) it appears to be a young radio source ($< 10^4$ years, Perlman et al. 1996, A. J. **111**:1839.), which has not yet produced kilo parsec scale radio lobes. Our HALCA+VLBA image have resolved compact jet components near the core, and future observations will measure the angular velocity of these components.

INTRODUCTION

Our research addressed the question of why is 1413+135 so variable at high frequencies, yet nearly constant at low frequencies. The high time variability of 1413+135 at 8 GHz, a 50 % increase in 0.3 years, indicates it has components smaller than 0.08 pc. This corresponds to an angular size of 35 μas for redshift 0.247, assuming $H_0 = 100$ km/sec/Mpc and $q_0 = 0.5$.

1413+135 is one of a sample of 5 sources selected from the NRAO Interferometer monitoring program. The sources in our sample have a large range of redshift and optical identification type (see Table 1). The radio source, 1413+135, is compact, < 0.1 arc seconds in extent, and is a VLA calibration source. The source was monitored daily by the Green Bank Interferometer (GBI), between October 1989 and June 1994. It was the remarkable GBI data (Waltman *et al.*1992, Figure 1) which brought our attention to this source. 1413+135 is highly variable at 8.3 GHz, while having a nearly constant flux density at 2.3 GHz.

We began our studies of 1413+135 to discover why is 1413+135 so variable at high frequencies, yet nearly constant at low frequencies. *Answer*: The compact core of 1413+135 is faint at lower frequencies, while at higher frequencies the lobes are. At frequencies lower than 3 GHz, the parsec scale jets of 1413+135 produce most of the emission. The outer regions of the jets are not rapidly variable in intensity, while the core is highly variable.

Perlman *et al.* 1996 have published excellent images of 1413+135. These images did not resolve the central component of 1413+135, but did show the spectral properties of the outer regions which explain the nearly constant brightness of the 1413+135 at lower frequencies. Perlman *et al.* 1996 find no conclusive evidence for motion of the components of 1413+135 on scales larger than 2 mas. Their measurements of the spectra of the jets, along with limits on the temperature of the gas surrounding 1413+135, are consistent with a young or recurrent model for the source.

IAU Name	Survey Name	Source Type	Red Shift	Note
0201+113	OD+101	AGN	3.560	
0923+392	4C39.25	QSO	0.699	Alberdi 1993
1116+128	4C12.8	AGN	2.118	
1413+135	OQ+122	BL Lac	0.247	Highly Variable
2344+094	OZ+073.5	Seyfert I	0.673	

OBSERVATIONS

1413+135 was observed at C band on 1997 July 21 with the NRAO VLBA and HALCA. The VLBA only image of 1413+135 at C band is shown in Figure 2 *(top)*. The HALCA+VLBA (Figure 2 *bottom*) data resolve the more extended "lobe" components, and show the jet components close to the core.

The HALCA+VLBA image has approximately 3 times the resolution of the VLBA only image, as expected. The image clearly shows the jet is composed of several components. The improved resolution should allow measurement of jet motions over a 1-2 year period. Also note that the HALCA+VLBA image recovers 95%of the single dish flux of 1413+135. The more extended components of 1413+135 visible in the VLBA only image are resolved out in the HALCA image, but contribute only a small amount to the total flux density of the source.

Still higher resolution and more frequent observations of 1413+135 are needed to explain the high core variability. We have obtained, but not yet reduced, a second epoch of HALCA+VLBA data for 1413+135. We will use these data to measure the rate of angular motion of the inner jet components. In order to explain the high variability of the core, bulk relativistic motions of energetic particles are predicted. A prediction of the "young" source model is that components close to the core will show relativistic motion.

If 1413+135 has a structure similar to that of 4C39.25 (eg Alberdi *et al.*1993), then close to the core the jet must be oriented within a few degrees to the line of sight, but must rapidly curve away from the line of sight, in order to explain the low expansion rate of the outer components of 1413+135.

Planed future Space VLBI missions will provide sufficient sensitivity and resolution to resolve the core of 1413+135. GBI monitoring of 1413+135 has resumed, and the data suggest that 1413+135 appears to have begun a quiescent period.

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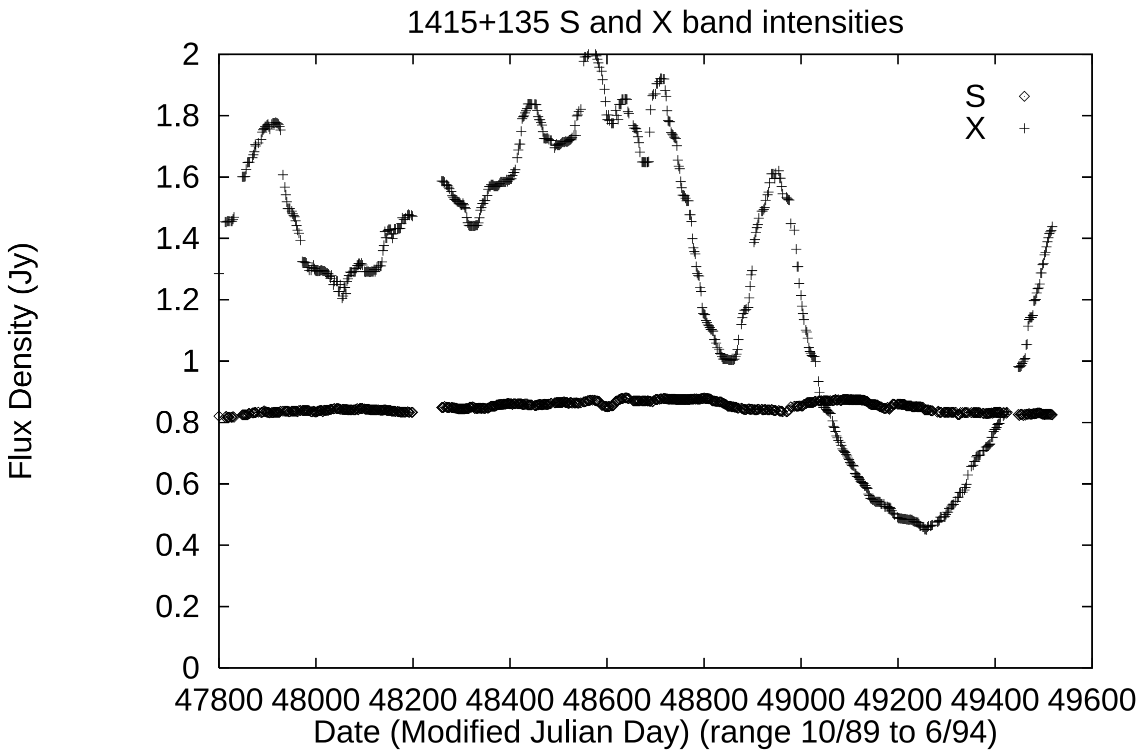

Figure 1: Plot of the X and S band flux densities of 1413+135 versus time. The nearly constant line at 0.8 Jy is the S band Flux density, and the variable line is the X band flux density. Note there is significant variation with in a 3 month interval. The intensity versus time plots are shown for the other sources in our sample.

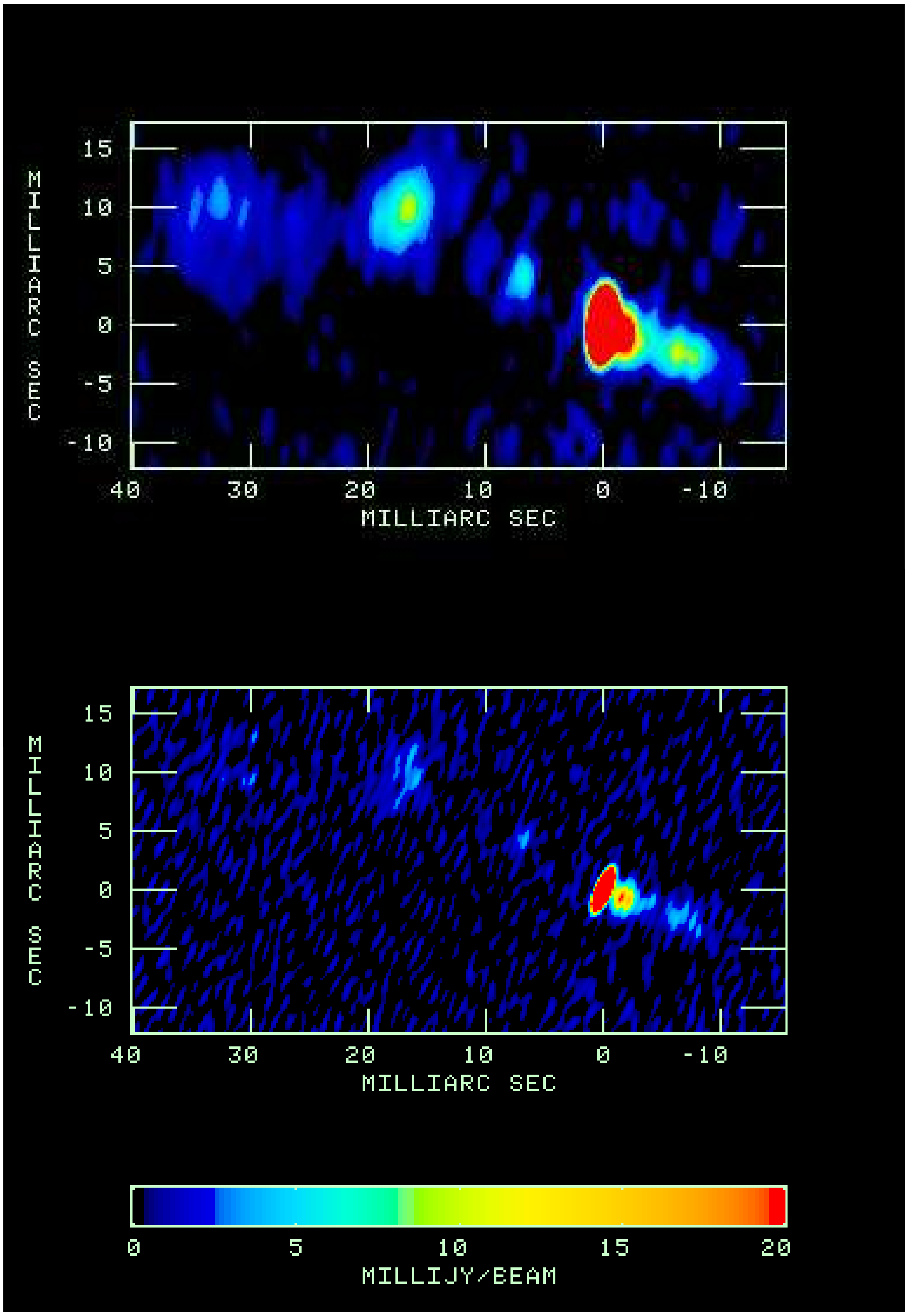

Figure 2: *(top)* VLBA image of 1413+135 at C band. Synthesized beam width 3.61 × 1.91 milli arc seconds, position angle 16.8 degrees. Both images have 0.0002 arc second square pixels. *(bottom)* HALCA plus VLBA image of 1413+135 at C band. Synthesized beam width 2.06 × 0.47 milli arc seconds, angle -26.3 degrees.