Radio Patrol Camera for Supernovae Search

T. Daishido, K. Asuma, S. Inoue, K. Nishibori,
H. Ohara, S. Komatsu
Waseda University, Shinjuku-ku, Tokyo
K. Nagane
Suginami-ku, Tokyo

1. Introduction

Zwicky started extragalactic supernovae patrol using 10 inch Schmidt camera about fifty years ago. After that the research of supernovae was accelerated, because the wide view of the Schmidt camera made it possible to watch large field of the sky. The key technology of the Schmidt camera was its sophisticated optical system.

Anticipated next supernova in our Galaxy may be undetectable by the optical instrument due to the Galactic extinction. However, supernovae are now known to be intense radio sources after a year or so of the explosion. Even if the positions are beyond the Galactic center, the radio supernova could be observed using middle size radio telescope.

We are planning to construct the radio patrol camera to search transient radio sources like supernovae or Cyg X-3. Final goal of the radio patrol camera is 2 dimensional 64x64 = 4096 elements filled aperture, and it will be able to map the whole sky once a week with 10 arcmin resolution and the sensitivity of 30 mJy.

Using a pilot system at Waseda University, we have been able to develop the technology and the concept of digital optics for the radio patrol camera. The present pilot system is an eight elements 1 dimensional array. So, the picture points are eight. The wide view and the real time image formation have been established in this system.

RF frequency is 10.6 GHz and bandwidths are 20 MHz. Phase and Amplitude are automatically controlled by the digital complex amplitude equalizers. Design of two dimensional systems in progress of 8x8 and 64x64 are discussed.

2. Concepts and Devices in Digital Optics

Optical lens distinguishes the arrival directions of light by focusing the light to the corresponding positions on the photographic plate or CCD. Phase differences against position on the lens due to the arrival direction are removed through the focusing process, because at the focusing position only the power of a certain direction is superposed in phase. In other words, the arrival direction of wave is gradient of phase; i.e. k = grad(phase). The above process of removing the phase difference is Fourier transformation. The phase addition or subtraction in Fourier transformation could be replaced by complex multiplication or 4 real multiplication and additions, since exp(ip+iq) = exp(ip)exp(iq).

In this way, lens could be constructed by the digital multipliers and adders. And one could say "a digital lens" for this imaging FFT processor.

3. 2D Array

Followings are brief design of 8 x 8 = 64 elements patrol camera which is now planning before the full system of 4096 elements. Collective aperture is 15m x 15m, which is same as the full system. So, the same sensitivity of 30 mJy and the same resolution is

https://doi.org/10.1017/S0252921100094410 Published online by Cambridge University Press

expected. Picture points are 8 x 8 = 64, and mapping speed is 64 times fast as that of a single dish. Room temperature receivers will be used, and their system temperatures will be about 100K.

Table 1. A Design of 8 x 8 = 64 2D Radio Patrol Camera

Analog part

Number of	elements	8 x 8 = 64	
RF	frequency	10.6	GHz
1st local	frequency	9.6	GHz
1st IF	frequency	1.0 - 1.1	GHz
2nd local	frequency	1.05	GHz
Baseband	frequency	-50 -- +50	MHz

Digital part

	A/D converters		Complex amplitude equalizer		Digital lens (FFT processor)	
Number	64 x 2		64		2D complex(8x8)	
Clock	20 -- 100	MHz	20	MHz	20	MHz
Dynamic range	8	bit	8	bit	8	bit

Image integrators	64
2nd integrator and switching	Digital Signal Processor

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https://doi.org/10.1017/S0252921100094410 Published online by Cambridge University Press