

## Polarimetric Observation of Comet C/2009 P1 Garradd

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### ABSTRACT

In the present work, we report the preliminary results of imaging polarimetry of comet C/2009P1 Garradd at phase angles  $28.2^\circ$ ,  $28.1^\circ$  and  $21.6^\circ$ . The polarimetric observations of the comet were carried out on 21<sup>st</sup> & 22<sup>nd</sup> of March, 2012 with the 2-m telescope of IUCAA Girawali Observatory, Pune, India & on 23<sup>rd</sup> of May, 2012 with the 1.04-m Sampurnanand Telescope of ARIES, Nainital, India. Both broadband and narrowband filters were used in the observation.

**Keywords:** comets; dust ; scattering; polarization ; extinction

### 1. Introduction

Comet C/2009P1 was discovered by Gordan J. Garradd of Siding Spring Observatory, Australia in August 2009. The first parabolic orbit of this comet was calculated by B.G. Marsden on 2009 August 15. At the time of discovery it was located at a distance of 8.7 AU from the Sun, nearly the distance of Saturn. Though the comet does not get very close to the Sun, it is an intrinsically bright comet. The CO rich comet C/2009P1 Garradd was at its closest approach of 1.55 AU to the sun on Dec 23, 2011 & passes within 1.27 AU of earth on March 5, 2012. Studies of the physical properties of

cometary dust are important for understanding the phenomena of comets as a class, and for understanding the formation and evolution of comets and the solar system. The best way of unveil the mysteries of this astronomical object is to study the light scattering properties of dust grains present in it. Cometary polarimetry in the continuum is a good technique to investigate the nature of cometary dust. The polarization is mainly based on the phase angle & wavelength. The study of the polarized light scattered by cometary dust provide useful information about the physical properties of the dust such as size, shape, composition, albedo and the distribution of the dust particles present in the coma of the comet.

Linear polarization studies, which are independent of the number of particles in the field of view (for optically thin media), give contemporary indications for the optical & physical properties inside the coma [13]. For this reason linear polarization measurement of several comets have been studied by many investigators ([1 – 10], [12], [14], [15], [19], [20], [21]).

The paper is organized as follows: in Section 2 we present observations and data reduction; our results are presented in Section 3 and conclusion in Section 4.

## 2. Observation & Data Reduction

The observation of C/2009P1 Garradd at phase angles  $28.2^\circ$ ,  $28.1^\circ$ ,  $21.6^\circ$  were carried out from IUCAA Girawali Observatory (IGO; long= $+73^\circ40'$ , lat= $19^\circ5'$ , alt=1000m) near Pune in India on 21<sup>st</sup> & 22<sup>nd</sup> of March, 2012 & Aryabhata Research Institute of Observational Sciences Sampurnanand Telescope (AST; long= $79^\circ27'$ , lat= $29^\circ22'$ , alt=1951m) near Nainital in India on 23<sup>rd</sup> May 2012. During the respective nights of observation comet C/2009P1 Garradd was substantially bright.

### 2.1 IGO Observation

The Comet C/2009P1 Garradd was observed in both Photometric & polarimetric mode with the help of 2-m telescope is opened at f/10 with a Cassegrain configuration. The CCD camera used for imaging provides an effective field of view of  $10.5' \times 10.5'$  on the sky corresponding to a plate scale of  $0.307$  arc sec pixel<sup>-1</sup>. Both broad band red filter ( $\lambda = 630$  nm,  $\Delta\lambda = 120$ nm) & narrow band filter ( $\lambda = 684$  nm,  $\Delta\lambda = 9$ nm) is used in the observation. The optical principle and design of the instrument are described in [17], [18].

### 2.2 ARIES Observation

Polarimetric observation of Comet C/2009P1 Garradd were carried out with 1.04-m Sampurnanand Telescope is opened at f/13 in Cassegrain mode. The focal plane instrument used was the ARIES Imaging Polarimeter (AIMPOL). The field of view of

CCD used for imaging is 8 arc-min in diameter on the sky & each pixel of CCD corresponds to 1.73 arc-sec. During the observation a broad band red filter ( $\lambda=630$  nm,  $\Delta\lambda=120$ nm) was used. The detailed description of the AIMPOL observational set up & working principle are given in [16]

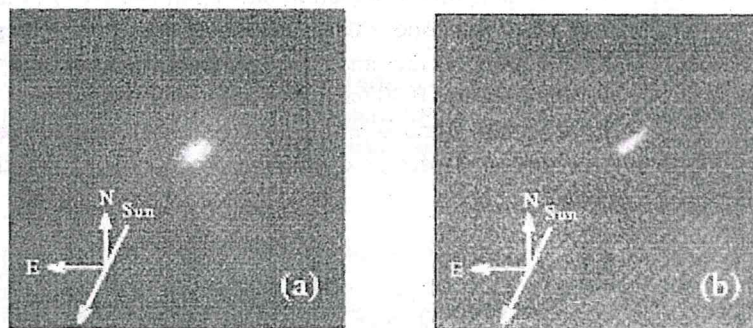
**Table1.** Observatory, UT date, heliocentric distance (R), geocentric distance ( $\Delta$ ), apparent total visual magnitude ( $m_v$ ), phase angle ( $\alpha$ ), position angle extended Sun – Comet radius vector (PA) and projected diameter for 1 pixel (D) during the observation

Observatory	UT date	R		$m_v$	$\alpha$ (°)	PA(°)	D(km pixel <sup>-1</sup> )	Filters
		(AU)	(AU)					
IGO, Pune(2m)	March21,2012	1.96	1.36	9.71	28.2	157.7	304	R <sub>c</sub> , R
IGO, Pune (2m)	March22,2012	1.97	1.38	9.75	28.1	153.9	307	R
AST, Nainital (1.04m)	May23,2012	2.52	2.75	12.41	21.6	101.1	3440	R

### 3. Results

#### 3.1 Intensity profile

Here we study the radial profiles through the intensity images by successful sky subtraction from each individual images. The decrease in intensity with an increase in the photometric center distance can be well noticed for both the period of observation. The slope of the intensity increases in the solar direction whereas the slope is found to be decreasing in the antisolar direction for both of the observational period. This variation is due to the change in the physical properties of the cometary dust in all possible direction which is an expected phenomenon for an isotropic coma.



**Fig1:** (a) The intensity image and b) The rotational gradient treated image at 28.1° phase angle on March 22, 2012

### 3.2 Aperture Polarization

The aperture polarization gives a well-defined idea about the size, shape & composition of the dust grains present in different apertures & thus it's a very significant tool to classify the comet. In our study we find the polarization value is very much symmetrical with the aperture changes. In AST observation as expected the negative linear polarization is being obtained at  $21.6^\circ$  phase angle.

To compare the linear polarization data of comet Garradd with other comets we collected the data of comets from the polarimetric database of comet [11]. Then the polarization (%) is plotted against phase angle ( $^\circ$ ) for both broad & narrow band red filters of IGO & broad band red filter of AST with other dusty comets. Our observed data are in fairly good agreement with the polarization values of other comets (shown in fig2). So from the figure it can easily be concluded that the comet Garradd belongs to a dust rich family with a high degree of polarization.

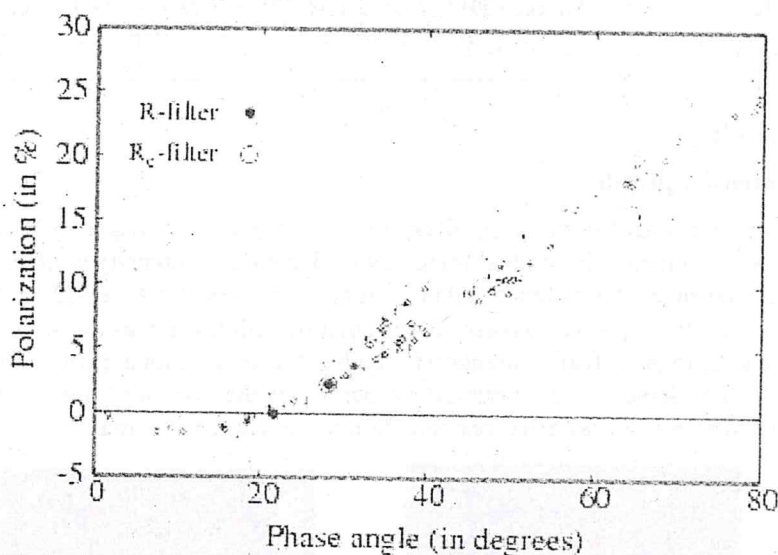


Fig2: Polarization vs phase angle plot of comet C/2009 P1 Garradd at R ( $0.630\mu\text{m}$ ) and Rc ( $0.684\mu\text{m}$ ) filter along with the other dusty comets.

### 4. Conclusion

- (i) The decrease in intensity with a gradual increase in the photometric center distance is being well noticed in both the solar & anti-solar direction. The slope is found to be much steeper in the solar direction than in the antisolar direction for both of the observational period.

- (ii) A prominent jet is well noticed in the solar direction elongated to a large distance up to 5000km from the photometric center during IGO observation which is the special feature of active comets possesses higher polarization.
- (iii) Our observed data are in fairly good agreement with the polarization values of other dusty comets. In the plot of polarization vs phase angle the position of C/2009 P1 Garradd indicates that it belongs to a family of dust rich comet.

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