RECENT OBSERVATIONS OF CASSIOPEIA A

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During the last few years radio and x-ray astronomers have produced high-resolution imagery of the remnant of Cas A. Since the most recent published optical photographs of Cas A date back to 1975 (Kamper and van den Bergh 1976 a, b) it seemed worthwhile to present new optical results based on plates obtained with the 5-m Hale telescope in 1976, 1977 and 1980. A photograph taken in 1980 is shown in Fig. 1.

The major changes that have taken place in Cas A during the last decade are: (1) A broken shell of fast-moving knots has formed along the southern and SW rim of the remnant and (2) A number of blue (oxygen-rich) filaments have developed to the north of the centre of Cas A. Figure 2 shows the locations of a number of knots of blue nebulosity that have become visible between 1977 and 1980. Knots F, G and K are visible in the blue-green [OIII] but not in the red [SII]; the other knots are fainter in the red than they are in the blue.

Measurements of 47 long-lived knots that were observed in 1976, 1977 and 1980 and for which observations had previously been published by Kamper and van den Bergh (1976) yield an explosion date $T_0 = 1658 \pm 3$ for Cas A. All of the knots used in this solution have been observed for a minimum of 10 years; 11 of them have remained visible over the entire 29 year period during which Cas A has been observed at Palomar. As was pointed out by Kamper and van den Bergh (1976) the recently formed blue filaments and knots in the SW part of the supernova shell have motions that deviate systematically from those of the other fast-moving knots. These deviant objects were excluded from the expansion solution given above. The system of blue knots yields $T_0 = 1598 \pm 43$. This indicates that the blue knots are expanding more slowly (at a marginal level of statistical significance) than is the rest of the remnant of Cas A. The observation that some knots are oxygen-rich, whereas others are sulphur-rich (Chevalier and Kirshner 1978) shows that the shells of differing composition in the

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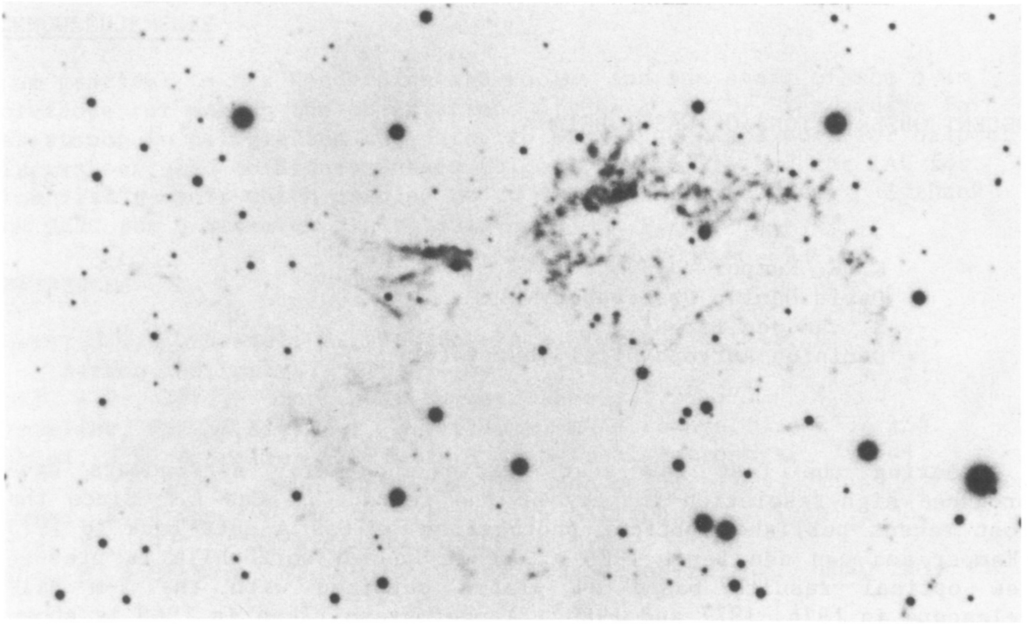

Fig. 1. Appearance of the optical remnant of Cas A in 1980 on a 100 min red (098 + RG 645) exposure.

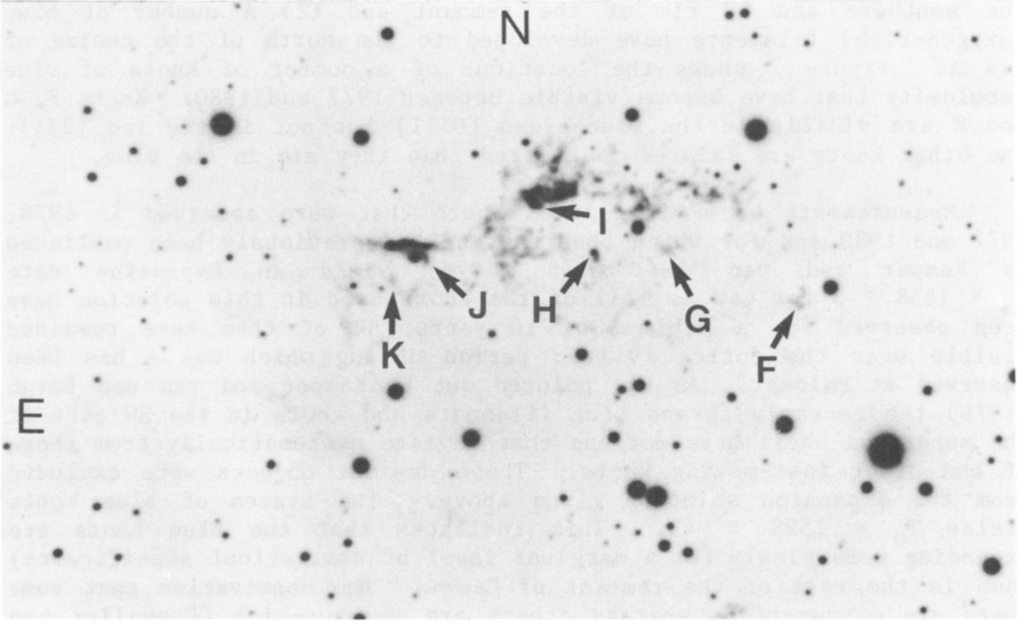

Fig. 2. Two hour blue (IIIaJ + GG7) exposure of Cas A obtained in July of 1980. Blue knots that have appeared since 1977 are marked.

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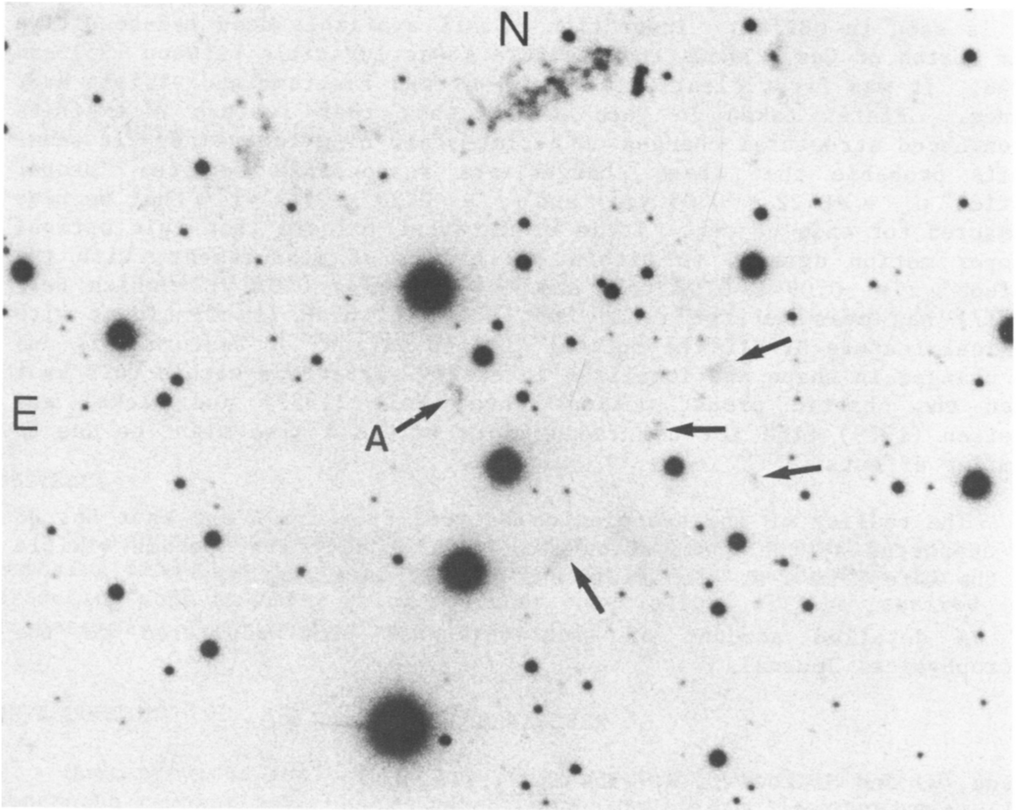

Fig. 3. Two hour red (098 + RG645) exposure obtained in July of 1976 of southern part of Cas A showing the faint quasi-stationary flocculi outside the main SNR shell.

supernova precursor were not well mixed during its detonation.

Ever since the pioneering investigation of Baade and Minkowski (1954) it has been known that Cas A contains two distinct types of objects; fast-moving knots that are oxygen-rich and contain no hydrogen and quasi-stationary flocculi (QSFs) that emit Balmar lines and [N II]. All previously known QSFs (Kamper and van den Bergh 1976) had $R < 130''$ and were located within the radio shell of Cas A. Recent work has, however, revealed the existence of a small cluster of very faint QSF's located ~ 150" SSW of the centre of expansion i.e. well outside the Cas A radio shell. These objects are indentified in Fig. 3. The nature of these objects is established by the fact that they are visible on broad-band red plates (H + [NII]) but are invisible on an [SII] interference filter plate and on plates sensitive to the blue-green [OIII] part of the spectrum. Confirmation of this conclusion has been obtained by Chevalier and Kirshner (1979) who find that a spectrum of feature A (which is the brightest of these objects) "shows strong emission lines of [NII] and $H\alpha$ along with weak [OI], just as is seen in QSF's". Inspection of all available deep red-sensitive 5-m plates of Cas A shows that feature A was invisible between 1951 and 1958. It was first clearly seen in 1967 and has remained visible ever since. Plates taken in good seeing show that feature A exhibits pronounced structural changes on a time-scale of a few years. It seems quite probable that these changes are responsible for the "proper motion" $\mu_\alpha = -0\farcs22 \pm 0\farcs05$ yr^{-1} and $\mu_\delta = -0\farcs20 \pm 0\farcs12$ yr^{-1} that we have measured for this object. It is of interest to note that this optical proper motion agrees, to within the errors of measurement, with the values $\mu_\alpha = -0\farcs09 \pm 0\farcs08$ yr^{-1} and $\mu_\delta = -0\farcs13 \pm 0\farcs08$ yr^{-1} which Bell (1977) has measured for radio knot No. 38, which is coincident with optical feature A. If the optical "proper motion" of feature A is due to changes in shape and localized intensity variations within this knot then the chaotic proper motions which Bell (1977) and Dickel and Greisen (1979) find for the radio knots in Cas A also might be due to similar effects.

The reality of the association between freature A and knot No. 38 is supported by the observation that this object first became visible in the late 1960's at both radio and optical wavelengths.

A detailed account of this work has been submitted to the Astrophysical Journal.

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