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# NGC1333/IRAS4 is an unstable triple

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**Abstract.**
SCUBA maps of the young multiple system IRAS4 reveal multiplicity of component 4B. We discuss the probable system configuration and find that the 4A-4BI-4BII system is probably unstable and will not survive in its present state.

## 1. Introduction

NGC1333/IRAS4 is a young multiple system comprising two main components, 4A and 4B, lying in an elongated extended cloud, presumably the remnants of an earlier collapse phase. Component 4A appears elongated at 450$\mu$m along the same axis as the larger cloud. This elongation is most likely a circumstellar disk, an interpretation which is strengthened by molecular line observations of a collimated outflow emerging in a perpendicular direction (Blake et al, 1995). 4A is known from interferometry to be a binary of separation 1.8" (Lay et al 1995). These authors found that 4B also seemed to be multiple, but the exact configuration of the system could not be determined.

## 2. Observations

We obtained SCUBA jiggle maps of NGC1333/IRAS4 at 450$\mu$m and 850$\mu$m. Beam maps were also obtained. The beam was deconvolved from the original maps using a Lucy-Richardson technique. The 450$\mu$m raw and deconvolved maps are shown in Figure 1. Cuts across the 4B system are also plotted.

## 3. The deconvolved maps

In the deconvolved map, we see that component 4A becomes a more sharply defined ellipse. This component is well fitted by a single elliptical gaussian, and so is still consistent the interpretation of a disk around the 1.8" binary. With

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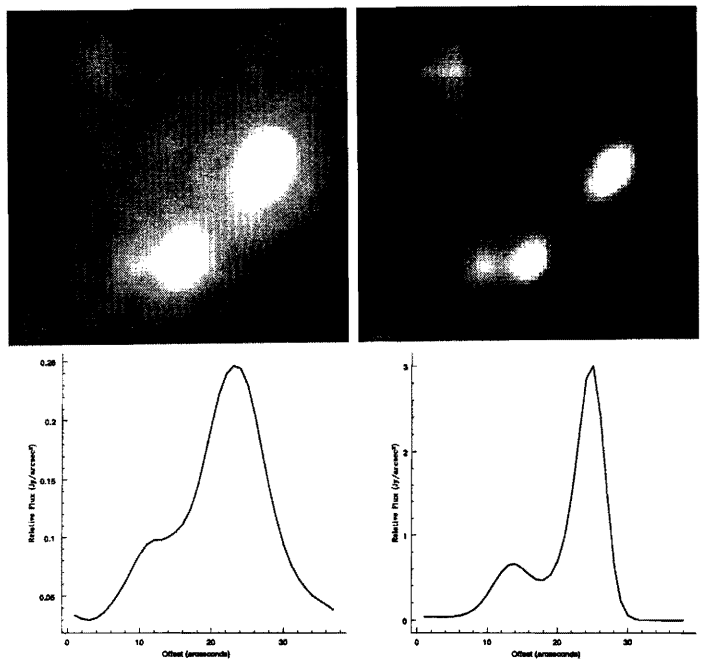

Figure 1. Raw and deconvolved maps of IRAS4, together with cuts across the BI-BII system.

this assumption, the disk would then be tilted at an angle of $53^o$ to the plane of the sky.

The 4B component, which in the raw maps appears elongated roughly East-West, is resolved into a binary of separation 15". If we assume the 4B system has an orbit coplanar with the 4A disk, this implies a true separation of almost 20" (7000AU at 350pc). Other configurations are of course possible, but most fragmentation models of binary formation are most likely to produce coplanar systems. Furthermore, if the 4A-4B orbit is coplanar with the 4A disk, this suggests that the 4A-4B axis lies close to the plane of the sky, given the fact that its projection is aligned with the long axis of the projected 4A disk.

## 4. Triple stability

Triple systems are generally only stable if they have hierarchical configurations, the binary component being relatively hard compared to the binary-triple separation. The 4A-4BI-4BII system appears to be close to instability, since the separation of the binary is a sizable fraction of the binary-tertiary separation.

Harrington (1977) developed a simple test of binary stability;

$$\frac{D_{triple}}{D_{binary}} > K\left\{1 + A\ln\left[\frac{2}{3}\left(1 + \frac{M_3}{M_1 + M_2}\right)\right]\right\}. \tag{1}$$

Here, $M_1$ and $M_2$ are the masses of the binary components, and $M_3$ is the mass of the stand-alone star. The ratio $D_{triple}/D_{binary}$ is the ratio of the periastron of the tertiary orbit to the major axis of the binary. The quantities $K$ and $A$ have values $K = 3.5$, $A = 0.7$ for a corotating system, and $K = 2.75$, $A = 0.64$ for a counterrotating system.

The most stable configuration is of course obtained by assuming the largest possible tertiary periastron $D_{triple}$, and the smallest possible semimajor axis for

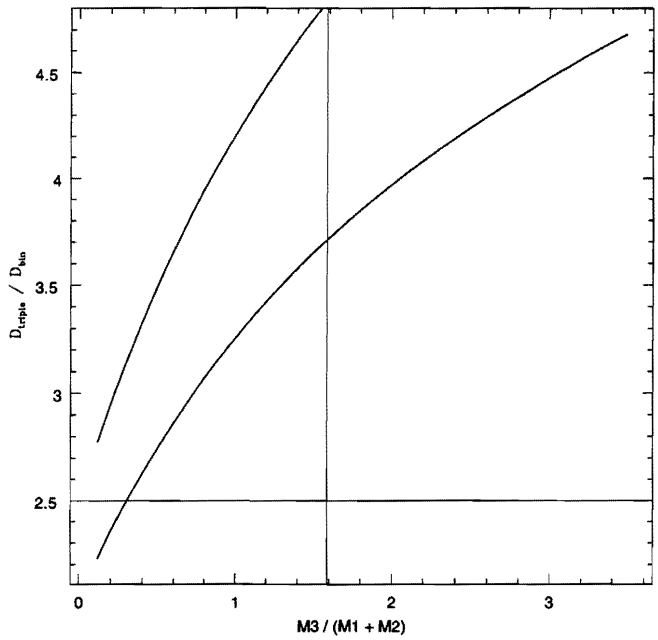


Figure 2. Stability criterion as a function of component masses. Values for IRAS4 are marked with the horizontal and vertical lines.

the binary orbit $D_{bin}$. The smallest possible separation for the BI-BII system is that observed. If the 4A-4B axis lies close to the plane of the sky, as seems likely given the shape of the parent cloud and the comparable elongation axis of the 4A disk, the maximum possible periastron of the 4A-4B orbit cannot be much larger than the observed 30" separation.

We therefore take $D_{triple} = 30''$, and $D_{bin} = 12''$. The counterrevolving case is more stable than the corevolving one. Masses for the objects are assumed to be proportional to their submillimetre fluxes, and a dust opacity index $\beta$ was obtained from comparison of the 450$\mu$m and 850$\mu$m fluxes and found to lie approximately in the range 2.0–2.5.

A graph of triple mass ratio versus separation ratio is shown (Figure 2). Stability curves for both corotating (blue) and counterrotating (red) systems are plotted. The values obtained for IRAS4 are marked as black lines. It is clear that IRAS4 is unstable according to the Harrington criterion, even if it is assumed to be a counterrotating system.

## 5. Conclusions

It seems that IRAS4 is an example of a young multiple system which has formed by fragmentation in an unstable configuration. It is therefore likely to disintegrate at some point in the future, giving rise to fewer, lower-order multiples.

## References

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