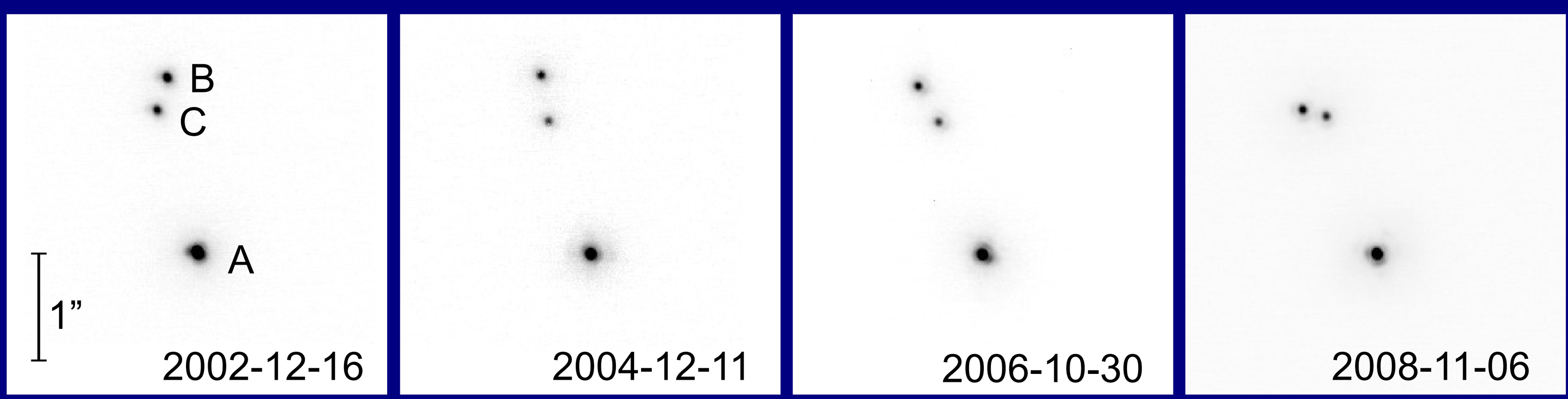
LHS 1070 - Individual masses of two very low-mass companions

Thorsten Ratzka[1] & Rainer Köhler[2]

[1]University Observatory Munich, Germany

[2]Max-Planck-Institute for Astronomy, Heidelberg, Germany

Determinations of the mass of stars close to the transition region from the stellar to the brown dwarf regime suffer from ambiguities due to a variety of theoretical models. The only way to overcome this unsatisfying situation is the astrometric monitoring of binaries to determine their orbital elements and to derive model-independent dynamical masses. If an astrometric reference point (e.g., the third component in a triple system) is available, it is possible to measure not just the relative, but the absolute motion of the stars in the sky. This allows to derive not only the total system mass, but also the individual masses. The found empirical masses serve the other way around to improve the quality of the theoretical masses predicted by the models.



Images of LHS 1070 taken between 2002 and 2008 in the Ks-filter with the adaptive optics system NAOS/CONICA (VLT).

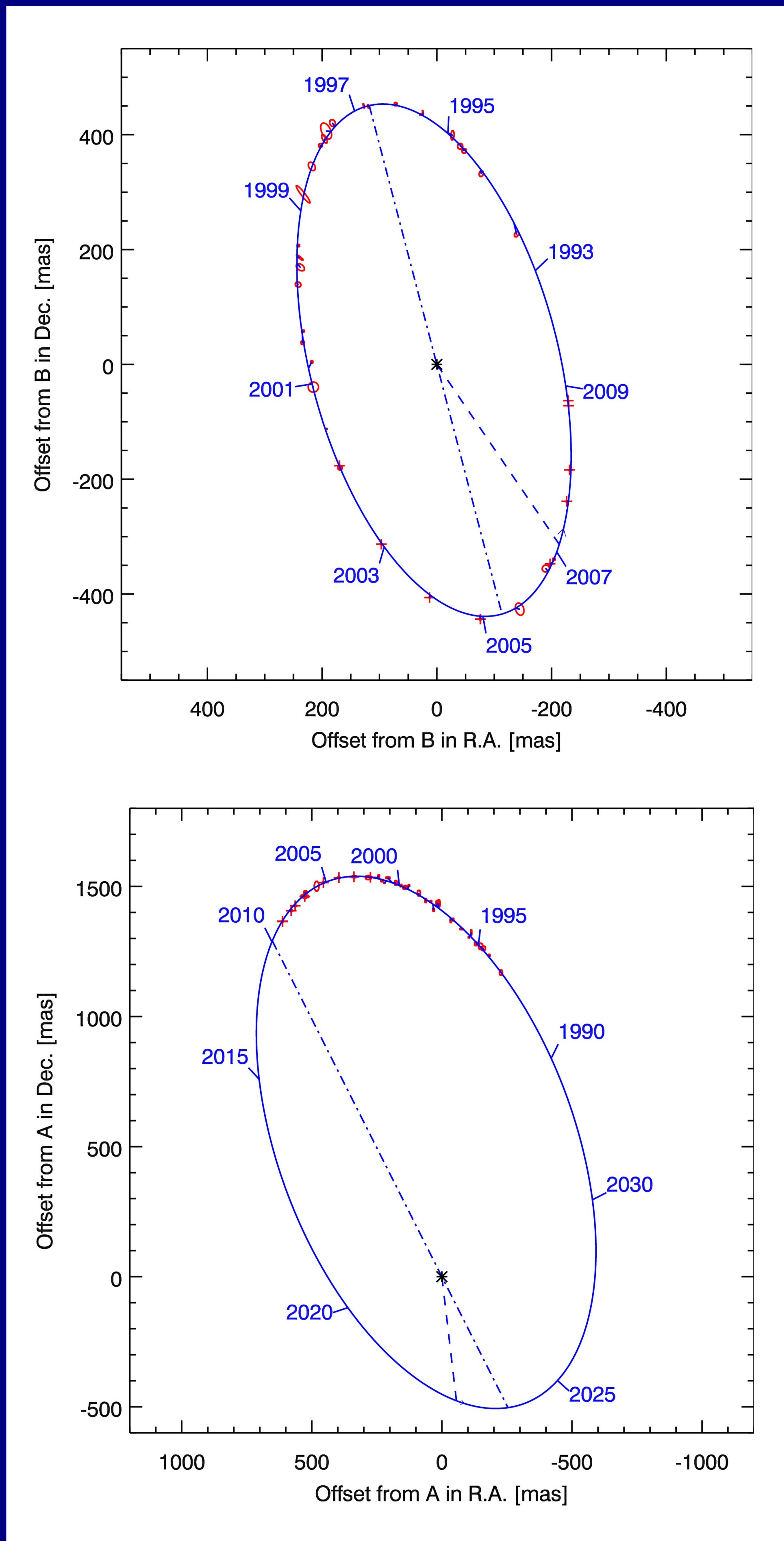
Discovered in 1993, the triple system LHS 1070 (other common name GJ 2005) is harbouring a M8.5V and a M9-9.5V component that revolve around each other in an orbit with a semi-major axis of about 0.5". Both together orbit around the primary, an M5.5-6 dwarf currently about 1.5" away. Costa et al. (AJ 130, 337, 2005) report a distance of 7.72 ± 0.15 pc for LHS 1070.

Its short period of about 17 years makes the close binary an ideal target for an orbit determination. Only such a short period allows a good sampling of the orbit. On the other hand, the resulting separations of the lower-mass companions are small. They can only be resolved due to the proximity of the system to the Sun and by using adaptive optics systems or Speckle interferometric techniques. At larger distances the semi-major axis of about 4 AU would be too small to be resolved.

We combined new NACO measurements of the triple system LHS 1070, yet unpublished Speckle interferometric observations and data from the literature to refine the orbital elements. The data now well sample almost a full period of the close orbit and a significant fraction of the wide orbit.

We follow the method that was used by Köhler et al. (A&A 482, 929, 2008) to derive the individual masses in the triple system T Tauri. Accordingly, the position of the center-of-mass of B and C is described in two ways. First, it is on a Keplerian orbit around A, which is described by 7 orbital elements. Second, the position of the center-of-mass can be computed from the observed positions of B and C, and the mass ratio (which is treated as a free parameter). Our model has therefore 8 free parameters.

Orbital Element	C around B	BC around A
Periastron [JD]	2454145.0 ± 1.4 (2007-02-13)	2459727.9 ± 3.6 (2022-05-28)
Period *P* [yrs]	17.24 ± 0.01	44.4 ± 11.9
Semi-major axis *a* [mas]	457.8 ± 0.4	1111.6 ± 1.1
Semi-major axis *a* [AU]	3.53 ± 0.07	8.58 ± 0.17
Eccentricity *e*	0.0227 ± 0.0004	0.5200 ± 0.0020
Periastron ω [°]	217.01 ± 0.08	147.16 ± 7.94
Ascending node Ω [°]	14.65 ± 0.06	26.80 ± 0.08
Inclination [°]	61.82 ± 0.04	54.75 ± 0.90
reduced χ^2	3.5	2.6
System Mass [$M_\odot$]	0.149 ± 0.009	0.321 ± 0.028
Mass Ratio M_C:M_B		0.92 ± 0.01



The orbit of component C around component B (top) and of their center-of-mass around component A (bottom). The observed positions are marked by their error ellipses. Lines connect the observed and calculated position at the time of the observations. The observations with NACO are marked by crosses. Their errors are too small to be discernible. The dash-dotted line indicates the line of nodes and the dashed line the periastron. Positions for various years are indicated.

We find from our fits individual masses of

$M_A = 0.172 \pm 0.010\, M_\odot$

$M_B = 0.077 \pm 0.005\, M_\odot$

$M_C = 0.071 \pm 0.004\, M_\odot$

Despite the still not satisfying coverage of the wide orbit, our fit shows that the close and the wide orbit are almost coplanar. The two orbits are inclined by 12.5° with respect to each other.

"Formation and Early Evolution of Very Low Mass Stars and Brown Dwarfs", ESO Garching, 11.-14. October 2011