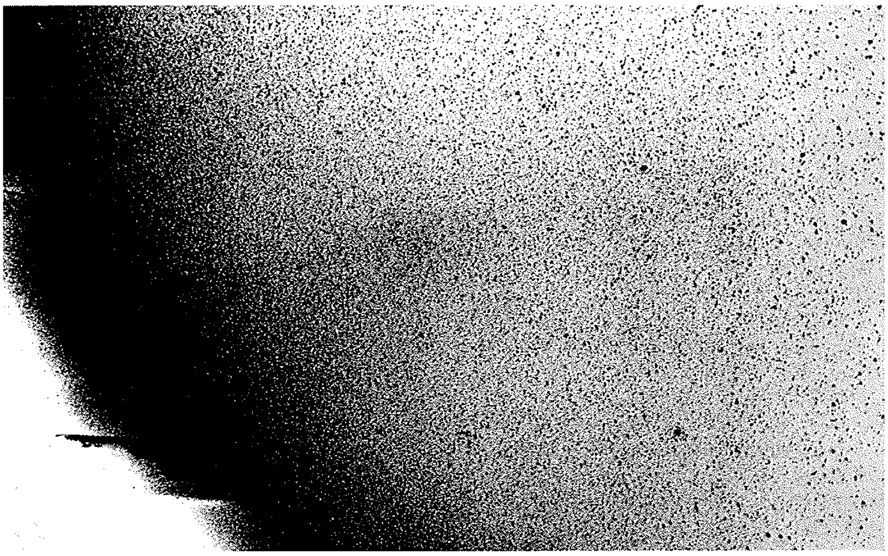

Figure 2: *Contrast-enhanced picture of the same photograph as Figure 1. Two bright stars have been marked to facilitate the orientation. Especially west of the gegenschein a separation of the light bridge is noticeable.*

antisolar point was at high galactic latitudes and the Milky Way did not interfere too much. Because of this, the zodiacal light bridge could be observed over a large extension along the ecliptic. Unfortunately, at the time of our observations (March 14, 1989) there was a strong airglow due to high solar activity close to its maximum, and the areas of the Ecliptic near the horizon were overexposed and the zodiacal light bridge had a low contrast.

The negatives obtained were either digitized and processed to false-colour images (Fig. 1) or contact-copied to increase the contrast (Fig. 2). Further techniques, like the correction of inhomogeneous illumination by the optics or subtraction of the stars, has not yet been performed. Especially the subtraction of stars would have been a good means to avoid any deceiving of the eye by star chains. In another step the scale of the picture was determined and the positions of the two bands appearing within the light bridge were marked, taking care that they did not influence the judgement of the pictures themselves. This procedure was repeated with three different pictures with various scales to improve the accuracy of measurement. Furthermore, the degree of error could be determined.

3. Results

All measurements over an ecliptical length of 70° in the region $140° \leq \lambda \leq 210°$ showed a separation of $6° \pm 1°$ of the bands within the zodiacal light bridge; this could also be established for the field of the gegenschein. Within the accuracy the bands are parallel to each other although one has the impression that they might diverge in the direction of increasing λ. The Southern band coincides with the Ecliptic and is more prominent, probably because it contains more dust. The deviation of the inclination will be studied with another set of exposures.

How far these bands agree with those observed by IRAS at different times and wavelengths remains to be seen, but it is at least possible by earthbound observations to see structures within the zodiacal light and to measure them. In particular, it will also be possible to make long-term observations which will throw more light on the constancy of this phenomenon. Other, still open questions are the inclination of the bands to the ecliptic, their intensity and how far they correlate with the distribution of the asteroids.

Here we only demonstrated that with a quite modest equipment new results can be obtained in this field of astronomy. Surely, the excellent conditions on La Silla contributed to this.

4. Acknowledgements

I am indebted to Prof. W. Schlosser, Bochum, for his suggestion to embark upon this subject and for his continuing support. Thanks are also due to the Director General of ESO, Prof. H. van der Laan, and also to Prof. L. Woltjer and Dr. R. West for permission to realize the observing campaign from La Silla. I also want to thank Prof. H. Debrunner, Bern, who gave me the opportunity to make observations from the Jungfraujoch observatory. My gratitude goes also to P. Riepe, Bochum, for the critical revision of the manuscript.

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Fundamental Stellar Quantities of Early-type Stars

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1. Background and Motivation

Absolute dimensions (masses, radii, luminosities) of massive stars are well known only for a few early-type stars, which comprise about 30 OB binaries of spectral types earlier than B5 and less than 10 O-type systems, while no reliable data at all are available for stars with $M > 40\ M_{\odot}$. However, especially for massive stars improvements in the theoretical treatment of the internal structure and stellar evolution have been reported during the last few years. Such new findings include convective core overshooting and continuous stellar wind mass loss with important implications for the stellar structure and temporal evolution of single and double stars.

There is an urgent need for an increase in the amount of high-precision

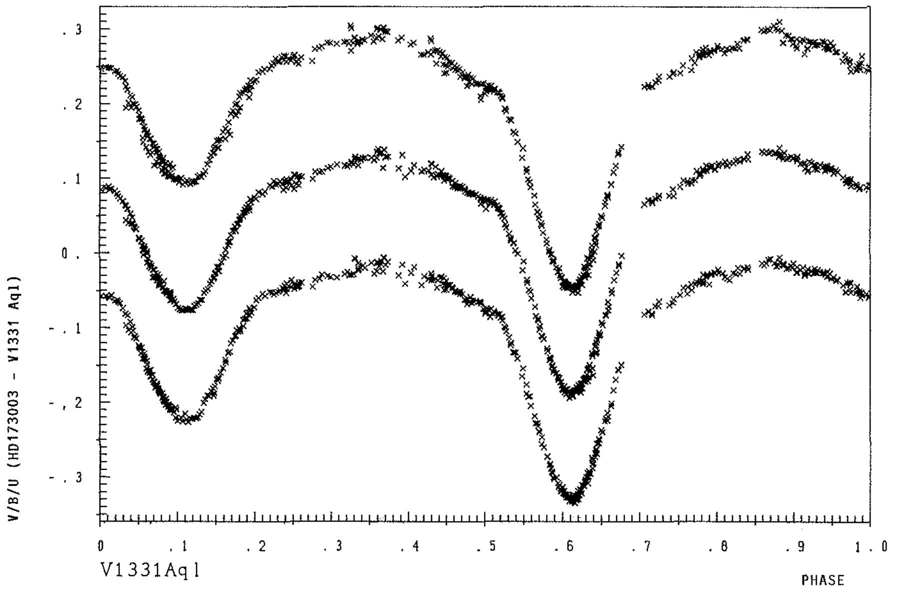

Figure 1: *UBV light curves of V1331 Aql obtained with the ESO 0.50-m telescope between June 15–29, 1990; individual measurements (U top, B middle, V bottom) are differential magnitudes in the sense: comparison (HD 173003) minus V1331 Aql. Ephemeris used is: hel. JD 2442610.0581 + 1ᵈ 3641953 E.*

absolute parameters of early-type stars to provide a statistically significant basis for a comparison of the actually observed properties with the revised evolutionary scenario. However, the absolute number of OB stars is relatively small, and there is an even greater deficit of "clean", undisturbed OB binary systems, which are by far the most important source of our knowledge of absolute dimensions. Most of these double-lined eclipsing binaries are close systems exhibiting a variety of interaction processes like tidal deformation, mass transfer and mass loss with immediate effects on the eclipse light curves and radial velocities.

Hence a programme has been initiated to analyse also complex systems with the main aim to derive fundamental stellar quantities and orbital elements as precisely as possible, and to enlarge the data base to be compared with stellar structure and evolution theory for massive stars.

2. Light Curve Solutions of Interacting Close Binaries

The various interaction processes in close early-type systems cause appreciable complications of the light curves. Frequently also a finite amount of third light (in triple or multiple systems and OB associations) introduces additional parameter correlations, which usually prevent convergent and unique solutions with classical methods. Therefore, flexible solution procedures are required, which take these complicating effects into account and make use of refined numerical methods.

The Wilson-Devinney approach based on the Roche model can handle tidal and rotational distortion, reflection effect as well as limb and gravity darkening in a satisfactory physical way. For hot luminous stars radiation pressure has to be considered as an additional important factor, which modifies the shape of the potential field. We furthermore use the nonlinear simplex parameter optimization procedure (Kallrath and Linnell, 1987), which is superior to the conventional differential corrections method in several respects.

The so-called *simplex* is a geometrical figure defined in the n-dimensional space of adjustable parameters, which can perform various operations like reflection, contraction, etc. The light-function values are calculated for each of the (n+1) vertices of the simplex, and the movement through the free parameter space is determined by a comparison of the corresponding sums of squared re-

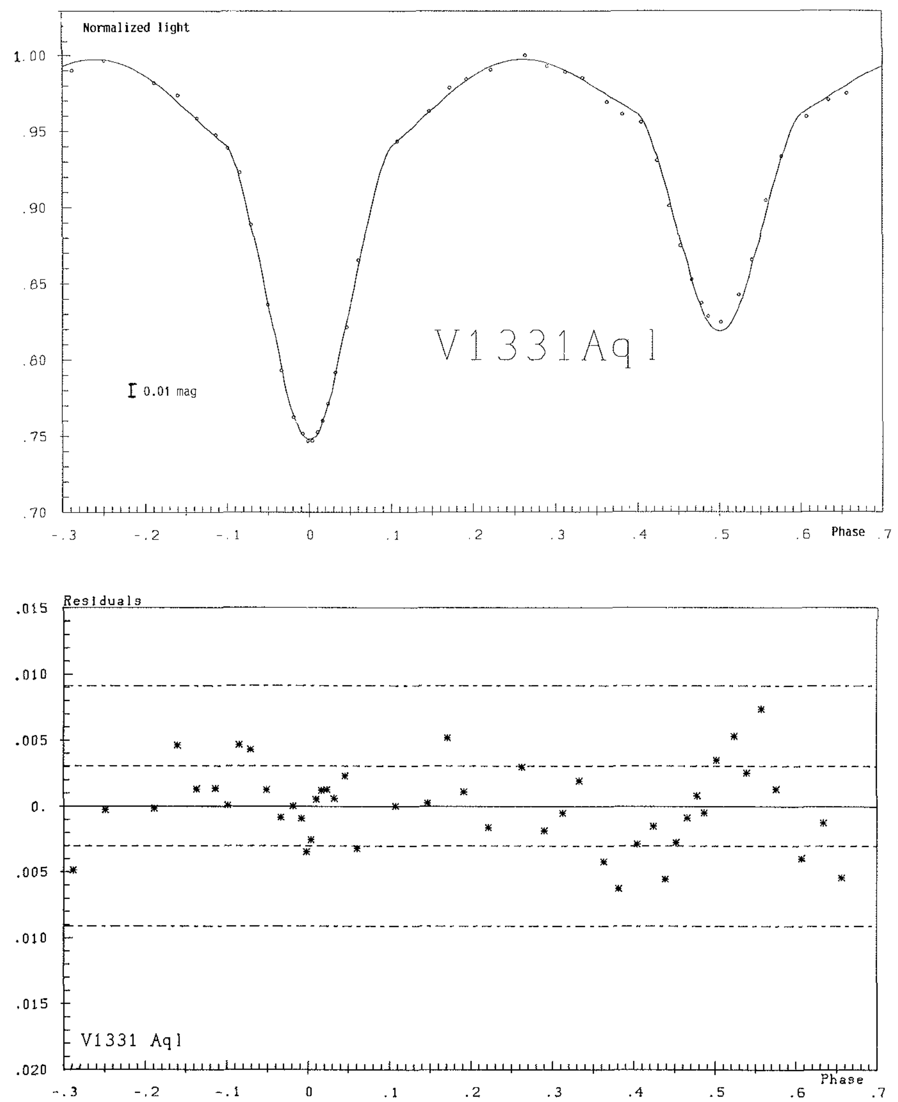

Figure 2: *V curve solution for V1331 Aql (top); dots are normal points, for which residuals are shown at bottom; solid line is mean value of residuals (very nearly zero), dashed lines give 1σ and 3σ belts.*

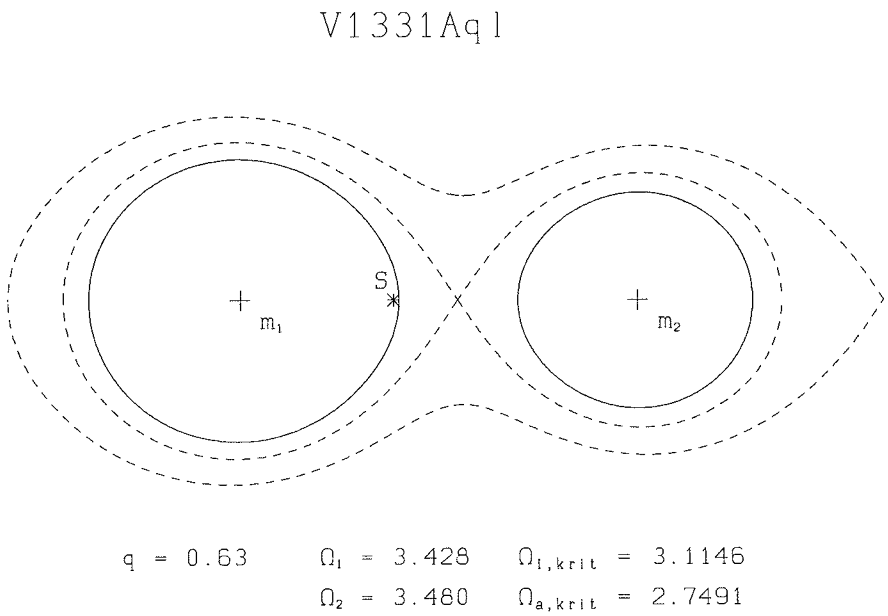

Figure 3: *Meridional intersection of the close detached system V1331 Aql; shown are both components together with inner and outer critical Roche surfaces.*

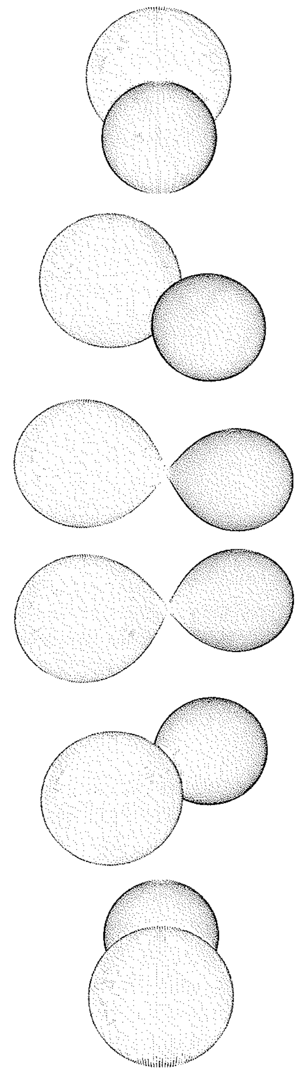

Figure 4: *Aspects of the massive contact system LY Aur (O9.5III + O9.5III, P = $4^{d}.003$) at orbital phases 0, 0.1, 0.2, 0.3, 0.4, and 0.5 (top to bottom).*

siduals. The simplex will eventually contract towards a locus in the parameter space at which best coincidence between observed and calculated light curves is achieved. The simplex algorithm exhibits a particularly good convergence behaviour, even for cases where the start parameter set is far apart from the final solution, and for systems with strong parameter correlations due to light-curve distortions and the presence of third light.

Our experience shows that the application of this modified Wilson-Devinney approach combined with a careful treatment of the spectroscopic information and other limiting boundary conditions can yield consistent system solutions and sufficiently accurate stellar parameters in many hitherto contradictory or unexplored cases.

3. A Few Recent Solutions

Table 1 summarizes photometric solutions and absolute dimensions of four recently analysed OB-type binaries, which should all be counted as difficult cases to complex light curves or third-light contributions.

V1331 Aquilae

This close eclipsing binary is of type B1V and has an orbital period of 1.364 days. Only scarce photoelectric measurements have been reported, and were solved with the classical Russell-Merrill method and Wood's WINK code in only one case. New UBV light curves were obtained with the ESO 0.50-m telescope between June 15–29, 1990. More than 500 individual measurements in each filter are shown in Figure 1.

Preliminary solutions converge to several possible values of the mass ratio q (= M_1/M_2), ranging between about 0.6 to 0.8, with nearly equally good fit quality. In all cases the system configuration is detached. The luminosity of the secondary is about three times lower than that of the primary, and its temperature turns out to be around 19,000 K (assuming 25,400 K for the primary). Both components are apparently not far from ZAMS. According to the spectral types, the masses amount to about 13 and 8 $M_\odot$, and the value of q should be close to 0.6. A very similar value of q = 0.63 resulted from our simultaneous solution of the UBV light curves. The V curve solution, together with residuals of normal points, and the derived system configuration are shown in Figures 2 and 3. Third light was a free parameter in all solutions, but converged towards neglectable amount. The final decision

Table 1: *System parameters of early-type binaries*

	V1331 Aql	AH Cep	IU Aur	LY Aur
T_1 (K) T_2 (K)	25400 19130	31500 29990	32000 28200	32100 28800
i (deg)	70.3	70.5[1]	88.3[1]	89.0
Separation A ($R_\odot$) R_1 ($R_\odot$)[2] R_2 ($R_\odot$)[2]	 0.37 A 0.28 A	19.8 6.4 6.0	18.7 6.5 6.5	38.7 17.9 14.7
M_1 ($M_\odot$) M_2 ($M_\odot$)	13:[3] 8:[3]	17.7 15.6	15.9 10.8	30.0 18.6
log ($L_1/L_\odot$) log ($L_2/L_\odot$) l_3	4.2:[3] 3.4:[3] 0%	4.58 4.52 5%	4.62 4.40 20%	5.51 5.32 10%

[1] for epoch 1984; [2] mean Roche radius; [3] ZAMS values.

about the mass ratio must be delayed until a spectroscopic determination of q will be available. It is planned to collect the necessary rv data in July 1991 at the ESO 1.52-m telescope (with ECHELEC).

It should be noted that in a review of early-type binaries by Hilditch and Bell (1987) two objects with very similar parameters appear: V Puppis (B1V, P = $1^{d}_{.}495$) and TX Aurigae (B1V, P = $1^{d}_{.}210$); these are semi-detached systems, with secondaries filling their Roche lobes. The detached system V1331 Aquilae therefore seems to be an important addition to the sample of the earliest binaries. In the following, a few more complex interacting binaries are briefly described, for which recent solutions were derived in the scope of this programme.

AH Cephei

AH Cephei (B0V + B0.5V, P = $1^{d}_{.}775$) is an early-type close detached system. Light curves from two widely separated epochs (1930 and 1984) with clearly different depths of eclipse minima were analysed. The derived time variation of the orbital inclination suggests the presence of a third body in the system, which manifests itself not only by light-time effect, but also by the precession of the orbital plane of the eclipsing binary. This finding is further confirmed by a fraction of third light of about 5 per cent, as is evident from the solution of the light curves. Besides IU Aurigae, AH Cephei is a unique example for a triple system, where the presence of a physical third component is not only proved by the light-time effect or third light, but also by a time change of the orbital inclination (Drechsel et al., 1989).

IU Aurigae

IU Aurigae (B0Vp + B0.5, P = $1^{d}_{.}811$) is a semi-detached system with the secondary filling its critical Roche volume. As in the case of AH Cephei, IU Aurigae is a rare case for which the presence of a third body can be confirmed beyond any doubt by light-time effect, third light of about 20 per cent, and in addition by the time variation of the orbital inclination due to the precessional motion of the binary orbit triggered by the third body (Mayer and Drechsel, 1987).

LY Aurigae

LY Aurigae (O9.5III + O9.5III, P = $4^{d}_{.}003$) is a massive contact system. A close visual field star with an angular separation of 0.5 arcseconds contributes appreciable third light to the total flux. This might be one reason for partly contradictory previous results concerning the mass ratio and system configuration. The recently obtained light-curve solution yields a third-light contribution of 10 per cent and a mass ratio of about 0.6, which is compatible with the spectroscopic value (Drechsel et al., 1989).

4. Future Prospects

We have shown that the sample of absolute dimensions known for very early stars can be enhanced by inclusion of interacting close binaries with hitherto unexplored or uncertain system parameters. The current programme not only aims at the measurement and solution of eclipse light curves, but will also complement radial-velocity data necessary for independent spectroscopic determinations of mass ratios, which are necessary for reliable photometric results. An essential subject of future investigation will be an adequate treatment of radiation pressure effects, which have already been shown (Drechsel et al., 1991) to be of major importance for the shape and configuration of early-type close binary stars.

Even at the end of the pre-VLT era and certainly also in the future, bright stars are far from being exhaustively explored. For good reasons, large instruments are not available for such objects, while medium- to small-size telescopes are still able to provide a wealth of important new data – especially if they are located at such marvellous sites like La Silla.

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Hunting the Brown Dwarf

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1. What are "Brown Dwarfs"?

During the seven last years there has been a considerable interest developing in view of the discovery and observations of presumed sub-stellar objects, also named "brown dwarfs". This illustrative term denotes a class of objects that appears naturally in the theory of star formation: recent models predict that the collapse and fragmentation of a molecular cloud should produce clumps down to 0.02 solar masses. Between this lower limit and 0.07 solar masses, the fragment is not massive enough to ignite nuclear reactions inside its core and ends as a "failed star", faintly shining in the infrared due to the release of gravitational energy associated with its progressive contraction. Observations of some members of this new class of celestial bodies would of course be of the highest importance for the theory of very low mass star formation, and models have been proposed which aim at predicting the photometric and spectrophotometric characteristics of brown dwarfs and their evolution with respect to their birth mass and age.

Another reason for the revival of this observational activity is of course to be found in several breakthroughs achieved in astronomical instrumentation, specifically at infrared wavelengths, which opened the door to the possible direct detection of at least the brightest, i.e. the youngest, brown dwarfs: high efficiency infrared arrays and diffraction-limited imaging techniques in the IR are prime weapons in this hunting.

2. First Attempts

The first observers to spot something were McCarthy et al. (1985). They used infrared speckle interferometry to detect brown dwarf companions possibly or-