COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 5076

Konkoly Observatory
Budapest
14 May 2001

HU ISSN 0374 – 0676

BINARY STAR MORPHOLOGY AND THE NAME OVERCONTACT

WILSON, R.E.

Astronomy Department, University of Florida, Gainesville, Florida 32611, USA

Rucinski (1997) has suggested that *contact binary*, rather than *overcontact binary,* be used as the logically and historically correct name for common envelope systems. He cites 5 recent examples within IBVS of *overcontact* being used in place of *contact*, and many more examples could be cited from the general literature. Rucinski kindly avoids assessing blame for the new trend, but the writer probably bears primary responsibility (Wilson, 1994, 2001). Although Rucinski interprets the cited examples as mistakes, it will be argued below that - in terms of both logical consistency and of history - those papers are using *contact* and *overcontact* correctly.

A literature survey shows the terms *critical lobe* and *limiting lobe* to be essentially interchangeable, with both referring to the largest closed equipotential that surrounds only one component of a binary. *Roche lobe* has the same meaning for some authors, while others use *Roche lobe* only for synchronously rotating, circular orbit cases. *Roche limit* is an infrequent synonym for *Roche lobe* that now seems out of favor, perhaps because the term has another meaning in regard to tidal disruption of satellites. G.P. Kuiper was probably first to understand the roles of critical lobes and first to use the word *contact* in a morphological context. His extensive paper on β Lyrae (Kuiper, 1941) developed morphological ideas quantitatively and demonstrated remarkable early insights into the mechanical equilibrium of close binaries. By *contact*, Kuiper meant contact between the two stars (p. 137 of Kuiper, 1941). Two new terms, *detached* and *semi-detached*, were coined by Z. Kopal (1955). The former condition has both stars within their limiting lobes and the latter has one star within its lobe and the other accurately touching (contacting or filling) its lobe. Kopal also used *contact*, but defined it to mean accurate contact of a star with its lobe (p. 427 of Kopal, 1955), in contrast with Kuiper's meaning. To Kopal, *contact binary* meant a binary with both star surfaces accurately coincident with their lobe surfaces. Obviously he did not believe in common envelope systems, as shown at many places in his writings - a view that now conflicts with observations of W UMa's and would even be considered unphysical. Nevertheless it will be argued below that Kopal's lobe-filling definition of contact serves morphology well and that we therefore need search no further for a useful definition.

Of course modern astrophysics is free to adopt whatever meaning of *contact* leads to the most consistent morphology, but let us examine history for perspective. Rucinski (1997) asserts that "The group of contact binaries was defined clearly by Kopal (1959, Sec. VII.6) as systems filling the common envelope encompassing both stars". However Rucinski's claim is not supported by a reading of that section. Kopal comments on the meaning of contact at only one place in his Section VII.6, which is in the middle of p. 526, where he states: "... both components of W UMa type systems appear to fill completely their respective Roche limits - a property which has earned them the designation of contact systems". Kopal also shows a schematic diagram of the three morphological types on his p. 483, where the illustrated contact system just fills the "figure eight" of the inner contact surface with no excess, so there is no common envelope. Then on p. 546 he specifically emphasizes the distinction between the Kuiper and Kopal definitions of contact, writing: "...whereas we propose to regard as contact binary (or component) a star whose surface coincides with its Roche limit, Kuiper's definition ...does not mean that mere contact exists, but a common envelope as well". Kopal had already made similar comments about contact systems at least 5 years earlier (p. 39 of Kopal, 1954; p. 149 of Kopal and Shapley, 1956). He avoided a problem with common envelope cases by disbelieving in them. So Kopal did define contact clearly, but not as contact between stars or existence of a common envelope as stated by Rucinski, but in the same way as contact is now most frequently used (*i.e.* accurate contact with a lobe).

Usage prior to 1994 usually involved a hybrid of the Kuiper and Kopal morphologies, with the Kuiper meaning of contact when the two stars are mutually involved (*contact binary* meaning that the stars touch) and the Kopal meaning for each star's relation to its lobe (*semi-detached* meaning that one star contacts its lobe and the other does not). Things would be simpler with *contact* having the same meaning for all morphological types, which they do in the Kopal scheme but not in the hybrid scheme. The hybrid scheme was formally inconsistent, but the inconsistency did not cause a practical problem within the 3-type morphology because, with synchronous rotation, contact of both stars with their lobes implied star-star contact. So common envelope systems were usually called contact binaries, although much less often (*e.g.* Wilson and Rafert, 1981; Wilson, Van Hamme, and Pettera, 1985; Wilson, 1988) they were called overcontact binaries - a name that reserved the word contact for its lobe-filling meaning while providing a pictorial name for common envelope binaries.

An extension or generalization of the Kopal morphology has come along in a fourth morphological type called *double contact* (Wilson, 1979). To appreciate the idea of double contact, one must recognize a generalized definition of a limiting lobe that applies for non-synchronous as well as synchronous rotation and for eccentric as well as circular orbits: *A limiting lobe is an equipotential for which the effective gravity is zero on the line of centers at periastron* (Wilson, 1979). Double contact becomes meaningful for super-synchronously rotating stars and involves filling of both lobes *without* star contact (not even point-contact), thus forcing a decision - does contact mean star-star or star-lobe? We shall have a consistent terminology regardless of whether rotation is synchronous if we keep the star-lobe definition, and any excess beyond lobe filling is well described by *overcontact*. The change in usage noted by Rucinski came after the name overcontact was coupled with an explanation of the 4-type morphology (Wilson, 1994). Rucinski prefers use of overcontact for binaries that overflow the outer contact surface, as in Kuiper (1941). Although such systems are exceedingly rare, Rucinski's preference is an entirely reasonable use of the name. However we need to agree on what overcontact is to mean and my suggestion is to continue using overcontact in the sense adopted in many recent papers and agree on another name for contact with the outer contact surface. Perhaps it can be as straightforward as *outer-contact binary*.

With regard to counter arguments, Rucinski says that "the equipotential is not a solid surface in space and there is nothing to be in contact with". However abstract surfaces certainly can be in contact - abstraction lies at the foundation of science. Actually the idea of contact always is an abstraction - the contact of material objects is as much an abstraction as the contact of mathematically defined surfaces. Of course, the surface of a star is an abstraction. Far from being impermissible, abstraction is a primary ingredient in scientific thinking. Therefore a star can certainly be in contact with its critical lobe. The concept has been used for many decades without stirring doubts as to its essential meaning and is a core concept of binary star morphology. Were we to grant that a star cannot be in contact with a non-material surface, we would have to admit that it cannot be detached from it either (detached from that which does not exist?).

In conclusion, Kuiper's common envelope physics was more in keeping with modern ideas than were Kopal's point-contact binaries, but the issue at hand is the meaning of the word contact in terms of history and logical usefulness. Historically, Kopal definitely meant star on lobe, not star on star. Logically, Kopal's lobe-filling definition avoids inconsistency and allows for a natural generalization to non-synchronous and eccentric orbit cases. Explanations of generalized 4-type morphology are in Wilson (1994; 2001) and on pp. 87-89 of Kallrath and Milone (1999).

I thank S. Wyithe for calling Rucinski's paper to my attention and W. Van Hamme for comments.

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