Here I am presenting three different approaches to study the *MMS*. First one (Section 3.1.1) employs the `FB-Sample`, i.e. the 48 contact binaries observed with the Kepler Telescope. Second approach (Section 3.1.2) is focused on the multicolor photometry of the `SUH-Sample`. This is also the only Section, in which I am extending the analysis on the multicolor photometry taken with the ground-based telescopes. Please note that beside this Section, all the LCMA works only on the Kepler-passband light curves. The third approach (Section 3.1.3) uses the numerical simulations. In there I am comparing the conclusions drawn from the observational data with the synthetic results. In the end (Section 3.1.4) I am showing an attempt to use the differential color analysis of the *MMS* to obtain some information on the temperature ratio in the systems in the `SUH-Sample`.

3.1.1 The Kepler data (`FB-Sample`)

Since most of the Kepler binaries do not have a spectroscopically determined mass ratio, I initially settled on ensuring the proper light curve phasing to satisfy $q < 1$. For that I constructed the `FB-Sample`, which consists of contact binaries, which light curves exhibit a flat-bottom minimum. The reasoning was as following. In case of W UMa-type contact binaries, according to the (Lucy, 1968b), the more massive star is always the bigger one. For the systems experiencing the total eclipse, i.e. with a high enough inclination, this leads to the secondary minimum having a flat-bottom profile. The objects in the `FB-Sample` were therefore rephased so that their flat-bottom minima would correspond to the orbital phase $\phi_{min_{II}} = 0.5\,\phi$.

Confirmation of the contact configuration

To confirm the contact binary nature of the `FB-Sample` objects I performed a numerical modeling of their light curves. The numerical modeling was performed on the averaged light curves consisting of all available observations from the Kepler Mission for a given object. I used the modified Wilson-Devinney code (Debski, 2012), the same as the one used in Chapter 2. I have not taken into account the phase smearing effect caused by the Kepler's Long Cadence exposure time. It was not necessary to incorporate it into the modeling, which main goal was to just confirm the contact configuration of the given system. To ensure this approach is valid, I have modeled 17 objects from the `FB-Sample`, which' solutions were found earlier in Zola et al. (2017), where the phase smearing effect was studied. The comparison of the results is shown in Tables 3.4 and 3.5, where for every object a pair of solutions in given. First, flagged in the second column as '1' is from this work and the one from Zola et al. (2017) is flagged as '2'. Please note the assumed temperatures of the primary components are differing between Zola et al. (2017) and this work. This is for the purpose of consistency of having the effective temperatures for all objects coming from the same source used the numerical modeling. I assumed the temperatures directly from the KEBC, which is the most complete published source of temperatures for objects gathered therein. The lion share of the best fitting models found in this work are very close to those found in Zola et al. (2017). The remaining pairs of results, which have a somewhat differing mass ratios, have also a different solution with respect to the introduced third light in the system. Please note that the choice of the effective temperatures fixed for the primary components play little role in the best fitting models. While the absolute temperatures do vary, the temperature ratio

TABLE 3.4: Best fitting models describing objects in `FB-Sample` as presented in Zola et al. (2017) (flagged #1) and this work (flagged #2).

KIC #		i [°]	T_1 [K]	T_2 [K]	T_2/T_1	$\Omega_{1,2}$	ff [%]	q	$L_1/(L_1+L_2)$	l_3
3104113	1	80.04	6535	6619	1.013	2.0644	93	0.1748	0.79922	0.0
	2	79.05(11)	5910	5994(1)	1.014	2.0498(4)	91	0.1666(2)	0.8027(5)	0.0
3127873	1	87.5964	6408	6168	0.963	1.9170	99	0.1094	0.87672	0.2839
	2	90.00b	6070	5702(3)	0.939	1.9242(2)	88	0.1093(9)	0.8837(31)	0.215(2)
5439790	1	82.9839	7022	6804	0.969	2.1765	39	0.1969	0.82079	0.0
	2	82.69(2)	6566	6411(1)	0.976	2.1686(2)	36	0.1921(1)	0.8237(6)	0.0
5809868	1	78.6978	7208	6484	0.900	2.0540	37	0.1446	0.88497	0.0
	2	90.00b	6880	6365(1)	0.925	2.1743(4)	47	0.2007(2)	0.8454(11)	0.208(1)
7698650	1	81.8350	6307	6261	0.993	1.9516	74	0.1161	0.86376	0.1328
	2	85.35(8)	6110	6082(1)	0.995	1.972(1)	70	0.1232(3)	0.8576(22)	0.159(2)
8145477	1	84.3508	6538	6284	0.961	1.9068	75	0.0988	0.89115	0.1804
	2	90.00b	6800	6496(2)	0.955	1.922(1)	65	0.1020(3)	0.8933(33)	0.159(2)
8265951	1	84.5858	6943	6707	0.966	2.1471	53	0.1919	0.8217	0.0
	2	79.38(4)	7044	6780(1)	0.963	2.076(1)	38	0.1540(1)	0.8565(2)	0.0
8539720	1	82.4242	6658	6402	0.962	2.0115	90	0.1480	0.84689	0.4748
	2	85.11(4)	6350	6119(1)	0.964	2.0378(3)	86	0.1581(2)	0.8426(19)	0.484(1)
8804824	1	88.5810	6556	6187	0.944	1.9386	75	0.1111	0.88839	0.2402
	2	90.00b	7200	6733(2)	0.935	1.9438(6)	67	0.1109(3)	0.8937(26)	0.192(2)

TABLE 3.5: Continuation of Tab. 3.4

KIC #		i [°]	T_1 [K]	T_2 [K]	T_2/T_1	$\Omega_{1,2}$	ff [%]	q	$L_1/(L_1+L_2)$	l_3
9350889	1	87.4030	6996	7037	1.006	2.0129	90	0.1485	0.82478	0.2374
	2	79.92(2)	6725	6749(2)	1.004	1.9173(2)	87	0.1060(1)	0.8702(9)	0.076(1)
9453192	1	85.1130	6622	6161	0.930	2.0196	61	0.1395	0.87607	0.2408
	2	89.51(6)	6730	6239(1)	0.927	2.054(1)	62	0.155(1)	0.8793(14)	0.269(1)
10007533	1	79.7629	6977	6401	0.917	1.8587	65	0.0792	0.92037	0.0
	2	83.16(5)	6201	6000(1)	0.968	2.057(1)	36	0.145(1)	0.8614(18)	0.166(1)
10229723	1	81.5483	6477	6262	0.967	2.0410	44	0.1419	0.86154	0.1680
	2	83.16(5)	6201	6000(1)	0.968	2.057(1)	36	0.145(1)	0.8614(18)	0.166(1)
10267044	1	79.4266	7103	6900	0.971	2.1337	55	0.1865	0.82291	0.0
	2	89.56(7)	6808	6700(1)	0.984	2.2463(1)	55	0.240(1)	0.7828(9)	0.150(1)
11097678	1	83.5109	6493	6425	0.990	1.8878	90	0.0951	0.88041	0.2682
	2	85.14(2)	6493	6426(1)	0.990	1.8928(1)	87	0.0967(1)	0.8792(5)	0.267(1)
11144556	1	76.8172	6803	6688	0.983	2.0305	98	0.1609	0.82289	0.3799
	2	76.84(2)	6428	6318(1)	0.983	2.0424(2)	97	0.1607(1)	0.8246(6)	0.370(1)
12055014	1	85.2819	6448	6356	0.986	2.0466	73	0.1562	0.83451	0.1315
	2	90.00b	6456	6439(1)	0.997	2.0606(1)	67	0.1598(1)	0.8346(9)	0.120(1)

TABLE 3.6: Best fitting models to the `FB-Sample` objects that required introduction of a starspot.

KIC #	i [°]	T_1 [K]	T_2 [K]	$\Omega_{1,2}$	ff	q	$L_1/(L_1+L_2)$	l_3	longitude	co-latitude	radius	temperature
2159783	80.0257	6140	6339	2.0270	68%	0.1455	0.81881	0.0000	19.8925	335.6767	17.2994	0.7500
2437038	82.3523	5461	5973	2.0659	86%	0.1715	0.74810	0.4410	58.4978	294.6309	13.2335	0.7500
2570289	86.3874	6360	6487	1.9345	91%	0.1143	0.84850	0.6966	72.1496	332.8059	10.2859	0.7500
3342425	87.7464	6306	6462	1.9059	100%	0.1050	0.85242	0.1004	40.9066	292.8499	10.6675	0.7500
4036687	82.4084	6200	6381	1.9811	96%	0.1367	0.81944	0.2706	14.7008	329.9027	16.7044	0.7500
4244929	85.8581	5976	6053	1.9952	100%	0.1447	0.81934	0.5326	9.1177	232.6977	21.9251	0.7500
5283839	86.5156	6239	6541	1.9550	91%	0.1229	0.82584	0.2191	29.5726	303.3711	13.6042	0.7500
5290305	81.5760	6542	6188	2.2020	43%	0.2107	0.82758	0.1787	33.1471	211.3514	14.4198	0.7500
6118779	78.3679	5715	6003	1.9133	93%	0.1060	0.84007	0.0000	26.9385	341.4695	13.7582	0.7500
7821450	81.4065	5155	5513	2.1743	38%	0.1955	0.75532	0.3150	28.8306	295.3447	10.3108	0.7500
8432859	84.8163	6352	6537	1.9565	92%	0.1241	0.83465	0.2008	19.3468	324.1026	16.2006	0.7500
8554005	83.4626	7298	7303	2.4571	59%	0.3562	0.70426	0.1819	39.1362	119.7208	10.1564	0.7500
8682849	78.9430	5631	5831	1.9579	80%	0.1206	0.83665	0.0000	21.4651	345.8011	15.7074	0.7500
8842170	79.2349	5589	5836	1.9808	96%	0.1365	0.81049	0.3867	11.3283	295.0217	21.5438	0.7500
9087918	80.0120	6085	6161	2.3049	32%	0.2514	0.76235	0.0000	6.1582	302.5093	21.1308	0.7500
9283826	80.0390	5987	6500	2.0716	70%	0.1663	0.76702	0.0000	9.2499	300.8311	23.3466	0.7500
10322582	75.1659	5863	6537	1.9664	83%	0.1250	0.78793	0.0000	27.3389	329.5999	19.6453	0.7500
10528299	80.9038	6302	6631	2.1781	42%	0.1998	0.77195	0.0000	9.9850	271.6615	21.3786	0.7500
10618253	84.3300	6580	6574	1.9449	84%	0.1165	0.85827	0.0000	16.3570	340.4166	15.9742	0.7500
11618883	87.5852	4347	4403	2.1805	80%	0.2253	0.75904	0.5836	9.9612	94.4058	25.8184	0.7500

TABLE 3.7: The results of the numerical modeling of light curves of the remaining 11 objects from the `FB-Sample`.

KIC #	i [°]	T_1 [K]	T_2 [K]	$\Omega_{1,2}$	*ff*	q	$L_1/(L_1+L_2)$	l_3
7601767	77.4303	6567	6388	2.1083	23%	0.1610	0.84835	0.2463
7709086	75.6680	6108	6290	2.1593	37%	0.1886	0.79296	0.0000
8143757	80.0228	5454	5592	2.2896	23%	0.2377	0.76388	0.0000
8265951	84.5858	6943	6707	2.1471	53%	0.1919	0.82174	0.1591
8496820	82.5074	6601	6558	2.0795	76%	0.1727	0.81689	0.0000
9030509	87.2324	5326	5393	2.0581	100%	0.1756	0.79271	0.2960
9151972	87.6551	5622	5716	2.0407	100%	0.1668	0.79816	0.5448
9703626	76.6434	6060	6088	2.2135	36%	0.2120	0.79266	0.0000
9776718	81.3253	7205	7277	2.0325	86%	0.1560	0.81769	0.0000
10395609	87.2058	6566	6564	2.0434	99%	0.1675	0.80956	0.2114
12352712	89.3545	6667	6469	1.8900	87%	0.0952	0.88770	0.2094

in the systems is very comparable (unless there are discrepancies between the Zola et al. (2017) solutions and mine in the third light parameter, which is understandable).

Out of remaining 31 objects in the `FB-Sample`, as much as 19 needed an addition of a spot to fully reconstruct the observational data. The best fitting models for those objects are presented in Table 3.6. It is interesting to point out that in all but one cases, the modeled cool spot was residing close to the longitude $\lambda = 270^\circ$, i.e. primary maximum was on average lower than the secondary one. The best fitting models for the remaining 11 binaries of the `FB-Sample` are shown in Table 3.7. Finally, it is worth noticing that out of 48 objects in the `FB-Sample` as much as 29 (60%) needed an additional third light to recreate the observational data. Although in must be pointed out that some objects are located in dense fields (e.g. KIC 2437038 is most probably associated with the open cluster NGC 6791) or have a bright visual companion (KIC 11618883 has a very blue, bright companion designated as Gaia DR2 2134927057714219520). In both cases the flux from the neighbouring stars is blended with the source binaries within the large pixels of the Kepler Spaceraft.

Measurement of the *MMS*

After subjecting the `FB-Sample` to `PerSiL` I obtained the separation of the brightness maxima on every epoch. I have calculated the *MMS* for each and every object and stored the results in Tab. 3.8. The Table contains the KIC number of each object in `FB-Sample`, the measured *MMS*, orbital period of the system and the effective temperature (Casagrande et al., 2010) of the binary, taken from the KEBC. Here I decided to take more precise estimates of the effective temperatures that those calculated for the Kepler mission. Effective temperatures calculated with the formula from (Casagrande et al., 2010) will be used in the statistical study of the `FB-Sample`. Inconveniently, not all objects in the `FB-Sample` have such effective temperatures calculated, therefore I could not use it in the process of the numerical modelling (which itself needed a consistent, yet not necessarily very precise temperatures, as shown in Tables 3.4 and 3.5). The main result at this point is that in all cases in `FB-Sample` the $MMS > 0.5\,\phi$.