The Stars of NGC 206

by *Scott N. Harrington* (© 2019)

Several years ago, while I was getting interested in all that there is to see in the Andromeda Galaxy (see my now completed *M31 Observing Guide*), I ran into a small controversy. I've now researched the answer to it pretty thoroughly and am here to present my findings. The question that I tried to answer is: ***Does the large OB association NGC 206, in the southwest flank of M31, contain the galaxy's very brightest stars visible to us amateur astronomers?***

Well, even though it has surprisingly little extinction, the short answer is no. The very brightest stars in M31 are scattered across the galaxy's disk and are actually one magnitude *brighter* than the brightest of NGC 206. At the end of the article, in Table 2, I'll go into detail about some of those. However, since that wasn't a very hard question to answer, I tried to answer the harder follow-up: ***Which then are the brightest stars of NGC 206?***

The challenge with NGC 206 (OB 78) is that since it has such a large apparent size (4.2'x1.5'), it has a high percentage of foreground stars overlaid on it. So correctly identifying which is a foreground star versus a member star takes serious study. In the 2016 paper by Massey et al. titled "A Spectroscopic Survey of Massive Stars in M31 and M33", they described the problem well saying, *"The foreground contamination is small for the blue supergiants (OB stars), where their very blue colors (*B − V *< 0) distinguish them from common foreground stars in the right magnitude range. But, as a massive star evolves, it may pass through a yellow supergiant (YSG) phase and then on to a red supergiant (RSG) phase. The lifetimes of stars in the YSG phase are* very *short (tens of thousands of years or even less), and studies of the numbers and luminosities of such stars have proven to be very useful tests of stellar evolutionary theory, but in this region of the [Hertzsprung–Russell Diagram] foreground contamination is overwhelming. Using radial velocities…only a few percent of the stars in this region of the [Color Magnitude Diagram] [are] actually yellow supergiants. The rest [are] yellow dwarfs in our own galaxy, as evidenced by their radial velocities. The contamination for the RSGs (*B − V *> 1.4) is large for all but the coolest and reddest stars, although foreground dwarfs can be weeded out using two-color."*

So it gets harder to confirm member stars of another galaxy as you get away from the blue supergiants. I've looked over the *B-V* values of all the stars spread over and around NGC 206 and used them to find the brightest supergiant members. While doing this, I found that what most amateur astronomers believe its brightest star to be (commonly known as "van den Bergh 137" or "Odewahn 12") is actually *not* a star! Sidney van den Bergh had hinted at its true nature in his 1966 paper when he said, *"Star No. 137 is a badly crowded blue star with [a visual magnitude of about 16.1]. If it is an association member [it has an absolute magnitude of -9]."* In an apparently obscure 2001 paper by Barmby & Huchra, it was found that its mass belied it was a young globular cluster (becoming known as BH05 thereafter in the *Revised Bologna Catalogue*). Its identity was refined in a 2010 paper by Hodge et al. when they used the *Hubble Space Telescope* (Figure 1) to find that it's actually one of the most luminous and massive young open clusters in M31. In that same paper they also found that it has a visual magnitude of +15.75 – which is pretty accurate considering it's visible in my 10-inch SCT at 140x.

Fig. 1 – BH05 (Hubble Space Telescope)

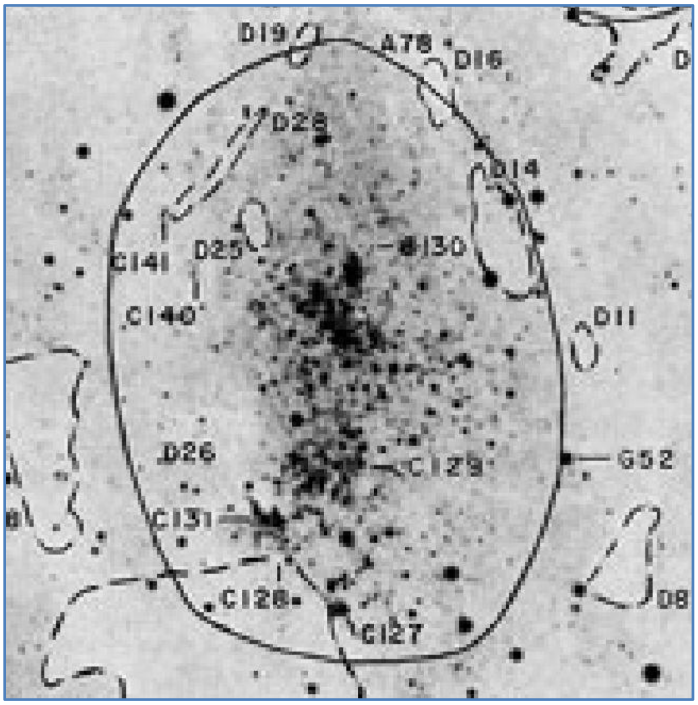

Fig. 2 – *Atlas of the Andromeda Galaxy* (Hodge 1981)

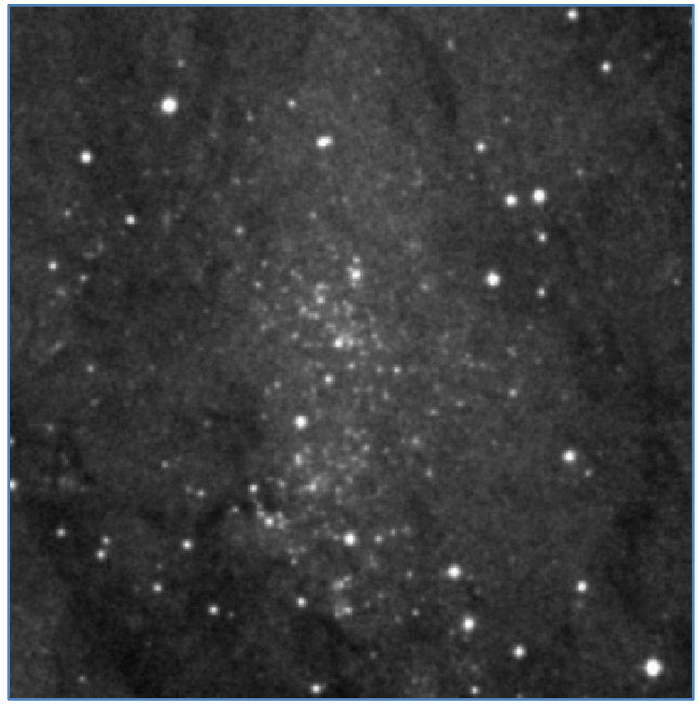

Fig. 3 – *Digitized Sky Survey* (Space Telescope Science Institute)

Fig. 4 – Subaru Telescope/ Hubble Space Telescope/ Mayall 4-meter

Fig. 5 – *Sloan Digital Sky Survey* (Apache Point Observatory)

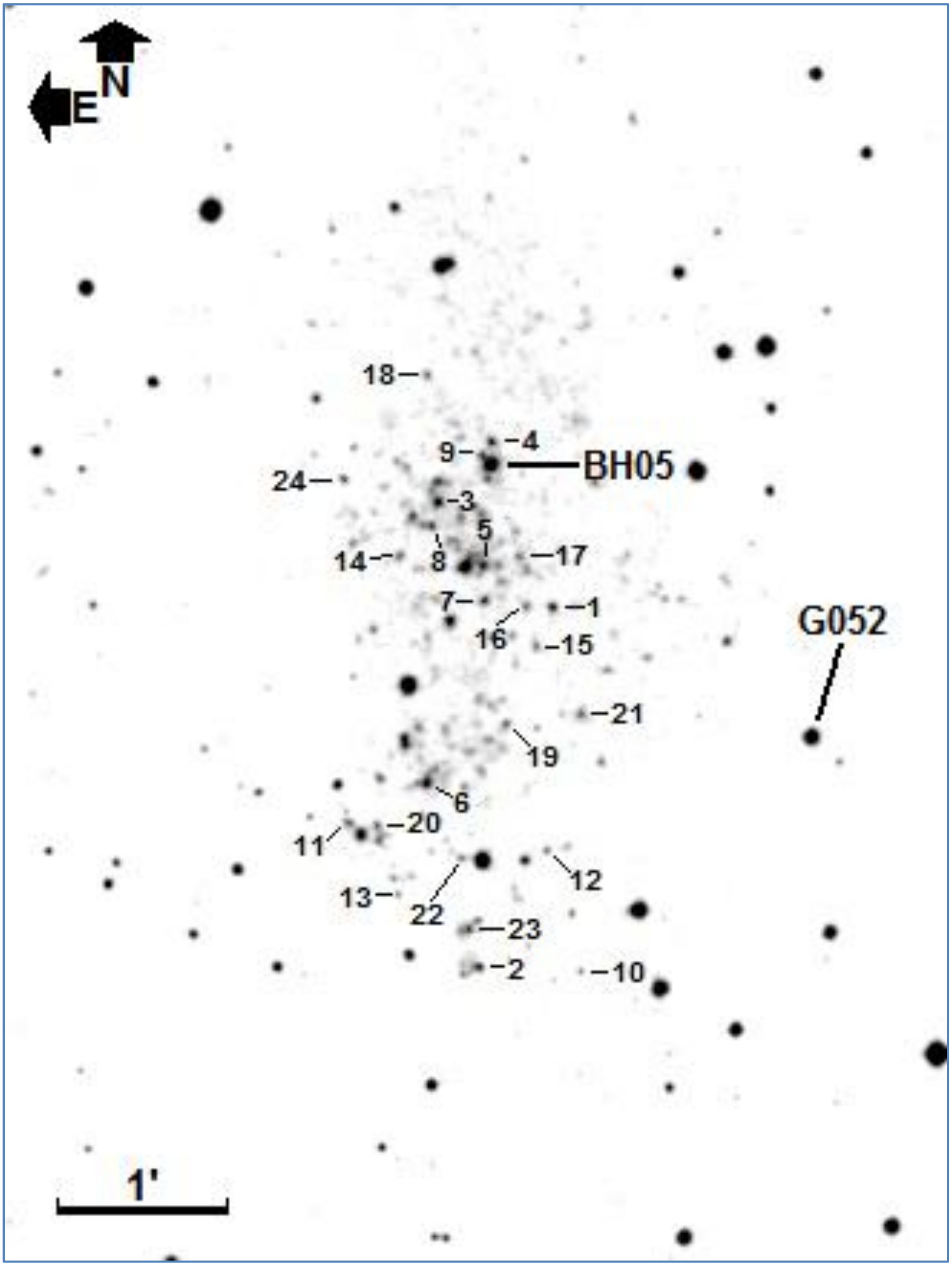

Figure 6 – *Note that the magnitude +15.5 globular cluster G052 is only labeled due to its relative proximity to the OB association.*

TABLE 1: Member Stars of NGC 206

All stars with a listed magnitude brighter than +18.50[1]

Map ID #[2]	van den Bergh #[1]	Odewahn #[3]	MAC # 1-[4]	Hill '95 #[5]	van den Bergh *V*	van den Bergh *B-V*	Odewahn *V**	Odewahn *B-V*	MAC *V*	MAC *B-V*	Hill '95 *B*
BH05	137	12	284	78-55	~16.1	--	16.06	-0.03	16.25	-0.15	16.13
1	34	60	163	78-30	17.42	0.10	17.12	0.13	17.14	0.00	17.25
2^	93	145	277	78-49	17.42	-0.22	17.35	-0.38	16.98	-0.18	17.26
3	11	22	419	78-79	17.49	-0.11	17.42	-0.35	17.21	0.06	17.28
4	2	8	293	78-57	17.66	0.05	17.43	-0.01	17.41	0.04	17.53
5	28	40	302	78-56	17.69	-0.14	17.62	-0.30	17.62	-0.10	17.59
6	62	97	427	78-78	17.70	0.21	17.63	0.05	17.65	0.19	17.81
7	40	54	297	78-59	17.72	0.17	17.60	0.09	17.64	0.03	17.73
8	22	32	478	78-89	18.02	0.06	17.95	-0.10	17.46	-0.22	17.75
9^^	1	10	314/ 319	--	18.04	-0.10	17.97	-0.26	18.23/ 18.69	0.16/ -0.06	--
10	99	144	114	78-19	18.06	0.07	17.98	0.03	18.00	-0.05	18.02
11	70	110	550	78-103	18.09	0.19	18.08	-0.03	18.03	0.07	18.16
12**	83	114	159	78-29	18.14	-0.08	17.97	-0.10	17.97	-0.05	17.94
13	73	129	485	78-88	18.19	0.11	18.16	0.01	18.24	-0.10	18.23
14	24	38	496	78-94	18.20	-0.05	18.00	-0.05	18.01	-0.09	18.01
15	35	68	185	--	18.20	0.17	18.13	0.02	18.10	0.14	--
16	33	58	209	78-37	18.23	0.04	18.14	-0.01	18.11	-0.08	18.15
17	30	37	223	78-39	18.26	0.12	18.19	-0.04	18.07	-0.02	18.13
18	3	4	453	78-85	18.27	0.19	18.02	0.34	18.10	0.01	18.21
19	53	84	239	78-42	18.28	0.31	18.29	0.08	18.44	0.22	18.44
20	76	111	516	--	18.31	0.35	18.24	0.19	18.30	0.37	--
21^^	112	82	119/ 126	78-21	18.40	-0.23	17.93	0.06	18.87/ 19.23	-0.15/ -0.32	18.13
22	81	120	--	--	18.89	>2.10	18.82	1.94	--	--	--
23	91	136	--	--	18.89	>2.10	18.82	1.94	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--

[1] – From van den Bergh (1966). Included are the two brightest red supergiants from both van den Bergh (1966) and Odewahn (1987), plus one that was not included in either.
[2] – From Figure 6
[3] – From Odewahn (1987)
[4] – From ***M***assey, P., ***A***rmandroff, T., & ***C***onti, P. (1986). They note that the measured *V* magnitudes in van den Bergh (1966) are *"a couple of tenths fainter than our photometry for the brighter stars [and] are as much as a magnitude too bright for the fainter stars in common (V ≈20)."*
[5] – From Hill et al. (1995)
*****– Odewahn did not list *V* magnitudes, but by using his *B* magnitudes and *B-V* values, the author was able to extrapolate for them.
****** – Was found in Trundle et al. (2002) to be a tight triple star using the *Hubble Space Telescope*.
^ – Possibly misidentified as an open cluster (C127) in Paul W. Hodge's 1981 *Atlas of the Andromeda Galaxy*
^^ – Noted as a double star in van den Bergh (1966)

All the stars listed in Table 1, except for van den Bergh 3, 53, and 76 (and of course the three red supergiants), have *B-V* values *repeatedly* measured below +0.25, meaning they are too hot not be members when you factor in their apparent visual magnitudes. As for the first three exceptions mentioned above, I'd say that they're "probable" members. There is one star I chose not to include even though I know some who consider it a member. I don't because the odds are more likely it's a foreground star due to its *B-V* value and visual magnitude (measured at +0.503 and 16.71 in 1992) along with its 1.10 *mas* parallax (GAIA DR2). The star is known as van den Bergh 71, Odewahn 112, or MAC 1-537 and lies in the SW corner of NGC 206.

Figure 6 was an image of NGC 206 labeled with over a dozen of its brightest member stars. For those with telescopes larger than mine and can see down to 17th magnitude and fainter, it's a worthy challenge to try and see any of them. That being said, I want to say that I know of many people who have looked at NGC 206 and seen a *"fine-grained mist of many stars that came and went with the seeing conditions"** with large telescopes and high magnification. To better understand those observations, I contacted several experienced observers to hear their firsthand accounts. I now believe that while some folks are catching sight of a few individual member stars with averted vision, the majority of them are seeing small clumps of member stars and non-member stars (the contamination is worse in NGC 206's southern "lobe"). Below are reports from three different observers using a 12.5", 16", and 48" telescope, respectively.

Gleaned from two 2016 Cloudy Nights threads, I found **Donald Pensack** wrote, *"Observing under magnitude 21.5 skies at an altitude of 8,350 feet, I and a friend were able to count about a dozen stars in NGC 206 with my 12.5-inch at around 300x – which means about six were supergiant stars in M31 (it's probably a foreground star in the Milky Way if you can see it with direct vision). Those stars are 2-2.5 magnitudes brighter than the average star in M31, so they are prodigiously bright and hot. The faintest ones you see will wink in and out and only be visible 10-20% of the time. The Bogan calculators indicate the limit of a 12.5" in perfect conditions would be around magnitude +17.9 – but who observes in perfect conditions? However, of the ten things it takes to have that, we did have seven of them present on that night. I've viewed NGC 206 many times since then and the six foreground stars are not all that difficult at that site, but seeing several more stars is less common. It seems that clarity of the air and good seeing is more important than perfect darkness or the highest magnifications.*

In a personal email to me, **Alan Whitman** wrote, "*On a very memorable night, September 14, 1999, the rare combination of both excellent seeing and transparency allowed me to glimpse blue supergiant stars in the O-B association NGC 206 with my 16-inch and an orthoscopic eyepiece giving 261x. I had been waiting for the perfect night to attempt these massive young stars with an intrinsic luminosity of about 250,000 times that of the Sun! The meteorological charts forecast that an upper ridgeline would pass over my observatory at 5am PDT. This meant that very good seeing was likely. In fact, it turned out to be excellent. By 3am my uncovered mirror had been cooling for eight hours. To preserve my hours of dark adaption, I dressed in the dark. M31 was near the zenith.*
NGC 206 was overlain with the four or five brighter Milky Way stars that are normally seen. But behind them were perhaps eight stars flickering in and out of visibility at the limit of vision. I carefully checked four areas immediately surrounding NGC 206 of the same size, but did not see any stars at the edge of vision in those areas. So I am confident that the majority of the glimmerings that I saw were indeed some of the about 70 blue supergiants that are so prominent in NGC 206 in the color photograph of the galaxy taken by the Palomar 48-inch Schmidt. While there are other O-B associations within M31, nowhere else in Andromeda is there such a marked concentration of blue supergiants. A careful examination of the photograph afterwards showed eight blue stars that were definitely brighter than the association's other supergiants, matching my observation. So the brightest stars in the Andromeda Galaxy are within the grasp of a 16-inch telescope on a perfect night!

Also in a personal email to me, **Steve Gottlieb** wrote, *"In November 2013, Jimi Lowrey and I used his 48-inch f/4 to carefully examine the large association NGC 206 in M31 for resolved stars. As a reference we used the finder chart in Stephen Odewahn's 1987 study* "A photometric survey of the rich OB association NGC 206 in M31"*. I assumed by having a labeled photographic chart at the eyepiece it would not be difficult to identify individual stars, but Odewahn's chart failed to capture the range in visual brightness of the Milky Way and cluster stars. As a result I had to carefully verify small patterns of stars (triangle, quadrilaterals, etc.) several times to feel confident of the identifications. After several minutes of observation, I had identified the 6 or 7 brightest members down to* V *= 17.6, as well as the superimposed Milky Way stars. The brightest "star"*

*To quote noted astronomy author **Bob King** in a personal email to me on the matter

[BH05] at the north edge was relatively prominent, but most were in the magnitude 17-17.5 range. Finally, I stopped carefully scrutinizing individual stars, relaxed my eyes and just gazed at the entire star cloud with averted vision. I was startled that in moments of good seeing, roughly 20 additional extremely faint stars popped in and out of view, mimicking the appearance of a dense open cluster or partially resolved globular cluster! Based on photometry in the paper, the magnitudes of the resolved stars extended down to approximately V *= 18.3-18.4. The cloud, itself, was quite irregular and split up into several slightly brighter patches."* After inquiring, Steve told me that he hadn't bothered to note exactly which member stars he saw.

I do want to mention French amateur astronomer **Bertrand Laville's** own studious drawing of NGC 206 with a 25-inch f/4 telescope. It shows more detail than any I've seen and can be found at his website www.deepsky-drawings.com (just make sure to have it translated by clicking "Select Language" in the upper left-hand corner!).

Now to the question of: *Which are the brightest[1] stars of M31?*

The answer to that has changed over the years as newer studies have come along and "corrected" it. In Table 2, you'll find a list of stars with their average visual magnitude being brighter than +17.00. Most have been listed as possible member stars in papers published in the last five years while the ones in **bold face** have been consistently listed in papers going back over a decade. That being said, I'd try to call these stars "probable" members in your observing notes because…well, you just never know. And please keep in mind that there are stars that didn't make my list as of right now but could be added in the near future!

TABLE 2: Brightest Probable Member Stars of M31

Average *V*[2]	Range *V*[3]	Local Group Galaxy Survey ID # or other[4]…	Berkhuijsen #[5]	Alternate Identification	Type[6]	In OB association[7]
15.61	0.14	LGGS J004406.32+420131.3	41-2142	--	F2Ia	--
16.024*	**--**	**LGGS J004057.86+410312.4**	**40-2637 (?)**	**[HIB95] 69-03**	**B1-1.5I**	**A69^**
16.16	**0.14**	**LGGS J004507.65+413740.8**	**41-3654**	**MAC 2-123**	**A2Ia-0e**	**A48**
16.19**	**--**	**2MASS J00451004+4136573**	**41-3712**	**MAC 2-203**	**A3Ia-0e**	**A48**
16.37	0.27	LGGS J004247.30+414451.0	41-962	--	F2Ia	A170
~16.40***	--	2MASS J00372064+4016376	--	LAMOST J0037+4016	LBV	--
16.465*	--	LGGS J004422.84+420433.1	41-2502	Bol D246	B0.5I	A165
16.53	**0.45**	**LGGS J004526.62+415006.3**	**41-4046**	**UCAC4 660-003111**	**LBV**	**A45**
16.68	0.11	LGGS J004434.65+412503.6	41-2788	--	B1:I	A39
16.69	0.13	LGGS J004021.21+403117.1	40-1672	--	F0I	A81
16.71	0.25	LGGS J004424.21+412116.0	41-2528	[HP J88] R-114	F5Ia	A33
16.71	0.05	LGGS J004518.76+413630.7	41-3898	MAC 1-587	F2I	A48
16.77	0.19	LGGS J003907.59+402628.4	40-367	--	F2-5I	--
16.77	0.13	LGGS J004129.31+405102.9	40-3332 (?)	--	F2I	A22^^
16.773*	--	LGGS J004428.12+415502.9	41-2621	--	K2I	A111
16.91	**1.30**	**LGGS J004333.09+411210.4**	**40-4564 (?)**	**AF And**	**LBV**	**--**
16.94	**0.36**	**LGGS J004450.54+413037.7**	**41-3230**	**Var A-1**	**LBV**	**A42**
16.95	0.12	LGGS J004207.85+405152.4	40-3913 (?)	--	F5I	--
16.96	**0.04**	**LGGS J004051.59+403303.0**	**40-2506**	**--**	**LBV**	**A82**

[1] – Not to be confused with the most *luminous* stars of M31, which aren't necessarily the brightest *visually*.
[2] – From Martin & Humphreys (2017) after eliminating those listed as foreground dwarfs in Gordon et al. (2016) and those with a GAIA DR2 parallax more than 0.25 *mas*.
[3] – Variability ranges are from Martin & Humphreys (2017). For more current figures, see *Multi-Epoch BVRI Photometry for All Targets in M31 and M33*, an ongoing monitoring program maintained by John C. Martin (University of Illinois Springfield Henry R. Barber Research Observatory).
[4] – To correctly identify these stars on a map, the author suggests typing their coordinates into AladinLite. For example, the coordinates of 2MASS J00451004+4136573 are simply RA 00:45:10.04 Dec +41:36:57.3
[5] – From Berkhuijsen et al. (1988). A "(?)" denotes that the author couldn't be sure of the correct identification in the afore mentioned catalog due to a systematic error in both its RA and Dec that was first reported by Magnier et al. (1992).
[6] – Listed as such in SIMBAD as of November 15, 2019.
[7] – As they are labeled and their boundaries drawn by Paul W. Hodge in his 1981 *Atlas of the Andromeda Galaxy*
***** – From Massey et al. (2006) and not an average magnitude.
****** – From Berkhuijsen et al. (1988) and not an average magnitude.
******* – From Huang et al. (2019) and not an average magnitude. Is believed to be a newly identified luminous blue variable that has been measured ranging from V magnitude ~16.50 to ~15.20 over a ten year period and is currently near its dimmest.
^ – van den Bergh (1964) described it as an *"Association of bright blue stars. Contains a beautiful large triangular emission region with a very bright blue central star."* The star LGGS J004057.86+410312.4 is that "*very bright blue central star"* and according to Hodge (1981) lies at the very heart of an open cluster (C205).
^^ – van den Bergh (1964) described it as a *"Very compact clustering of moderately bright stars involved in bright emission nebulosity."* The star LGGS J004129.31+405102.9 is one of the *"moderately bright stars"* at the edge of the *"compact clustering"* (which according to Hodge [1981] is the open cluster C179) while the *"bright emission nebulosity"* is known as Pellet 258 from Pellet et al. (1976).

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