

Caldwell Objects

C1 through C80

An Astrophoto Album
by
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First Edition
June 2014

Introduction

The Caldwell Catalogue is an astronomical catalog of 109 bright star clusters, nebulae, and galaxies for observation by amateur astronomers. The list was compiled by Sir Patrick Caldwell-Moore, better known as Patrick Moore, as a complement to the Messier Catalogue.



The Messier Catalogue is used frequently by amateur astronomers as a list of interesting deep-sky objects for observations, but Moore noted that the list did not include many of the sky's brightest deep-sky objects, including the Hyades, the Double Cluster (NGC 869 and NGC 884), and NGC 253. Moreover, Moore observed that the Messier Catalogue, which was compiled based on observations in the Northern Hemisphere, excluded bright deep-sky objects visible in the Southern Hemisphere such as Omega Centauri, Centauri A, the Jewel Box, and 47 Tucanae. He compiled a list of 109 objects (to match the number of objects in the Messier Catalogue) and published it in *Sky & Telescope* in December 1995.

Unlike objects in the Messier catalogue, which are listed in the order they were discovered, the Caldwell catalogue is ordered by declination, with C1 being the most northerly and C109 being the most southerly, although two objects (NGC 4244 and the Hyades) are listed out of sequence.

Moore used his other surname to name the list as M for Moore was already taken by Messier, and the catalogue adopts "C" numbers to rename objects with more common designations. Since its publication, the catalogue has grown in popularity and usage within the amateur astronomical community.

My astrophotography efforts began in 1975 but my ability to obtain acceptable images was hampered by the need for lots of equipment and materials to process film and make final prints and lack of time to

adequately develop the skills required. That situation changed dramatically in 2004 when I purchased a Canon EOS 20D digital single lens reflex camera. Relatively quickly, the resulting images began to meet the quality standards I had set for myself and I began a concerted program of deep-sky astrophotography. Three books provided some of my inspiration:

- *Atlas of Deep-Sky Splendors*, Hans Vehrenberg, 1971.
- *The Messier Album*, John H. Mallas and Evered Kreimer, 1978.
- *The Cambridge Deep-Sky Album*, Jack Newton and Philip Teece, 1983.

Goals

- Photograph all the Caldwell Objects visible from my location in Prescott Valley, Arizona - Caldwell 1 through 80
- When possible display all the objects with identical image scale for size comparison
- Show that quality images can be obtained from modest-sized high quality equipment

The Cameras

- Canon EOS 20Da, 3504 x 2336 pixel CMOS, 8.2 Mpx
- Canon EOS 60Da, 5184 x 3456 pixel CMOS, 17.9 Mpx

The sizes of the imaging chips in the cameras are the identical APS format. As a result the 60Da has 1.48 times more pixels per inch than the 20Da. When images from the cameras are displayed at the same resolution on a computer screen, the images from the 60Da will be 1.48 times larger. Images obtained with the 60Da have been designated with an asterisk (*).

The Optical Systems

- Canon EF 180mm f3.5L Macro USM
- Canon EF 100-400mm f/4.5-5.6L IS USM set at 400mm f/5.6
- Takahashi Sky 90 with 0.8X focal reducer/field flattener - 405mm f/4.5

The Mounts

- Vixen GPDX equatorial mount with SkySensor 2000 on JMI Wheeley Bars
- Software Bisque Paramount MX equatorial mount on a permanent pier controlled by TheSkyX Pro and an Apple MacBook Pro laptop computer.

Focusing

Initially focusing was done manually while observing a star through a Canon Angle Finder C at 2.5x magnification. The quality of focus was checked by examining a test image on the camera's LCD screen. Unfortunately image focus varied significantly, resulting in refocusing and second or even third images being acquired.

Eventually a JMI Motofocus and a Bahtinov mask were added to the Sky 90 optical system. Focus was achieved by observing the Bahtinov diffraction pattern on the computer screen using Stack Labs' Nebulosity 3. This focusing method is vastly superior to the manual method and the need to repeat image acquisition was eliminated.

Image Acquisition

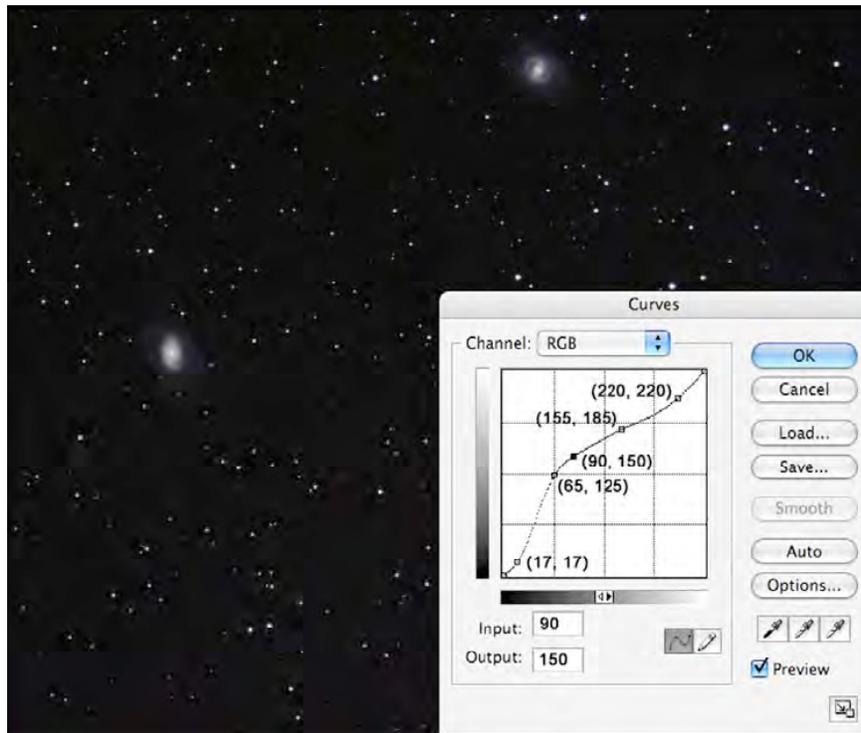
The basic image acquisition scheme was to obtain 5 dark-frames, then 30 light-frames and finally 5 more dark-frames, yielding an image set of 10 dark-frames and 30 light-frames for calibrating and stacking. Exposure duration of each frame was 1 minute at ISO 1600 (20Da) or ISO 3200 (60Da) with a 10-second delay between exposures and a 5-second delay from sequence initiation and the first exposure. No bias or flat frames were used. Images were saved as highest quality JPEG files on the cameras' memory cards. Image acquisition was controlled with a Canon Timer Remote Controller TC-80N3.

Basic Image Processing

The 30 light-frames were examined and any with bright satellite or

airplane trails were discarded. DeepSkyStacker 3.3.2 was used to calibrate and stack the good frames (usually 27 to 30) from each image set. The final raw stacked image file was saved as a 32-bit TIFF file.

Image enhancement and optimization was performed with Adobe Photoshop CS2. First the image file Mode was changed to 16-bit. While examining the upper right corner of the image, Levels was used to adjust the RGB black point such that $R=G=B$ at a value of 10-15.



Using Curves, the low intensity nebulosity was enhanced while not 'blowing out' bright zones or causing the black background to lighten significantly by setting Curves set points approximately as shown in the figure above.

Any resulting vignetting in background sky intensity was 'neutralized' using techniques similar to those described in "*Fixing Vignetting in Astrophotos*", Sean Walker, Sky & Telescope, September 2001 and the book *Photoshop Astronomy* by R. Scott Ireland. Finally a modest Unsharp Mask (amount: 100%, radius: 1.0 pixel, threshold: 3 levels) was applied.

The image scale of the three optical systems was determined using Adobe Photoshop CS2 and Voyager 4 Dynamic Sky Simulator. Then the image scale of the images from the Canon EF 180mm and Canon EF 100-400mm optical systems were up-sampled to match that of the Takahashi Sky 90 optical system for images obtained with the Canon 20Da. Images obtained with the Canon 60Da are displayed with image scale unchanged at 1.48 times that of the 20Da. Images were then appropriately cropped and combined to make the album pages with all the objects at the same image scale for direct comparison.

Final Thoughts

The images in the album were acquired over a period of 4.5 years with continuous improvement in equipment, techniques and skills. I am well aware that a number of images could be significantly improved and better photographs will be acquired in the future. In addition, a number of the planetary nebula are essentially 'stellar' in appearance and require significantly greater focal length and image scale yielded by larger OTAs to show detail. But 'perfection' can often be the enemy of 'finishing' so those better images await the second edition of this album.

Eventually I would like to obtain images of the 29 remaining most southerly Caldwell objects by subscribing to the internet telescope rental service iTelescope and use the equipment available in Siding Springs, Australia.

The Cameras



Canon EOS 20Da DSLR



Canon EOS 60Da DSLR

The Optical Systems



Canon EF 180mm f/3.5L Macro



Canon EF 100-400mm L zoom @ 400mm f5.6



Takahashi Sky 90 + 0.8x reducer/flattener 405mm f/4.5

Vixen GPDX Equatorial Mount with SkySensor 2000 on JMI Wheeley Bar



Software Bisque Paramount MX Equatorial Mount on Permanent Pier

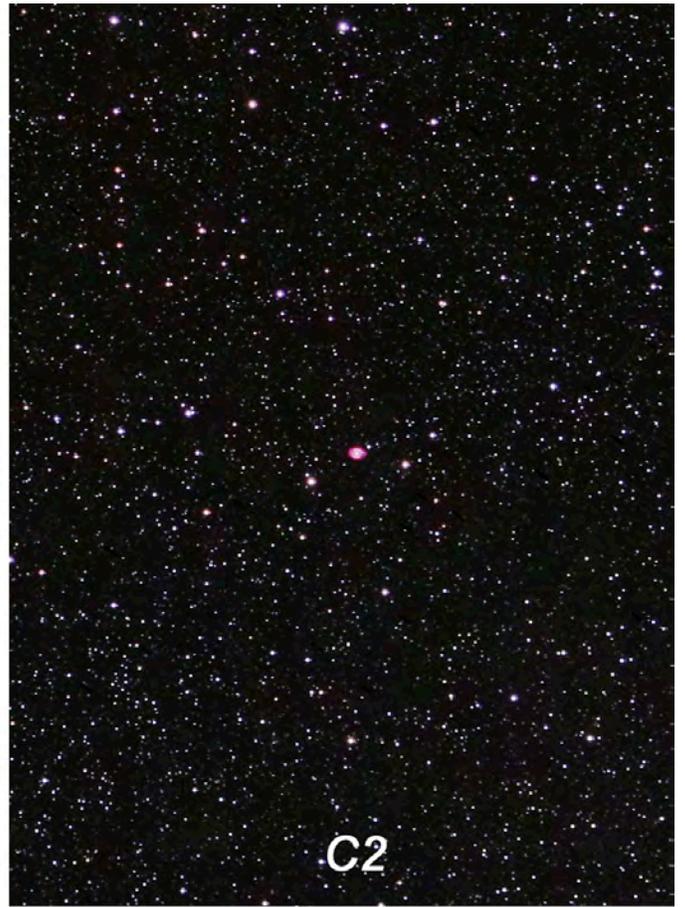
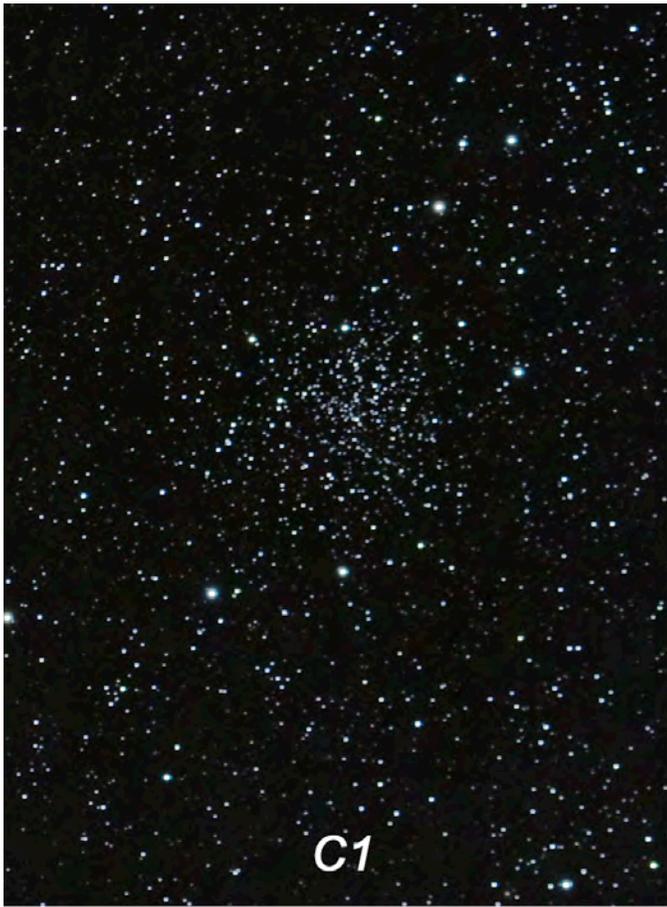


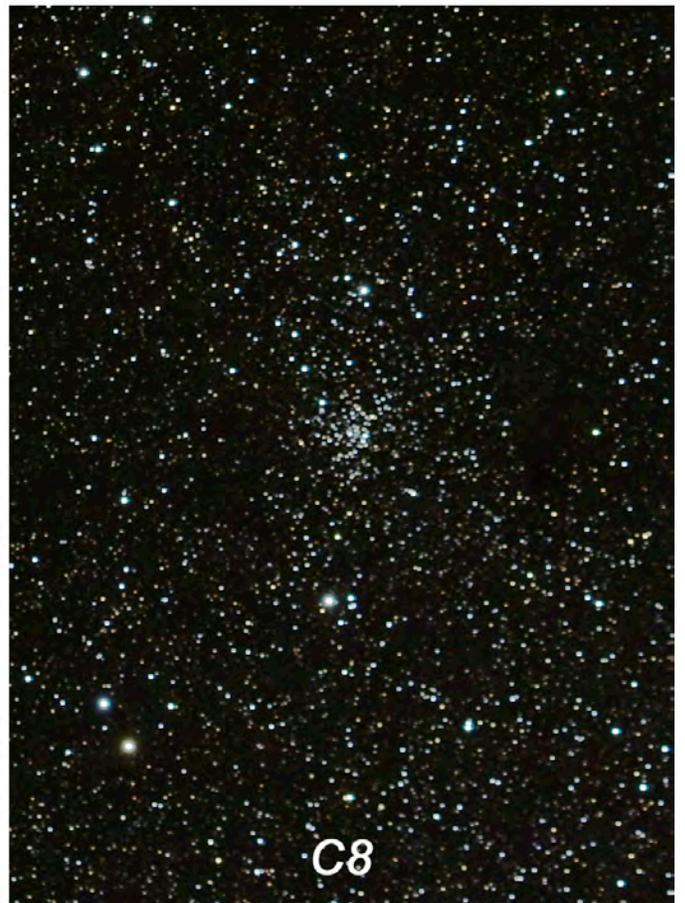
The Caldwell Objects

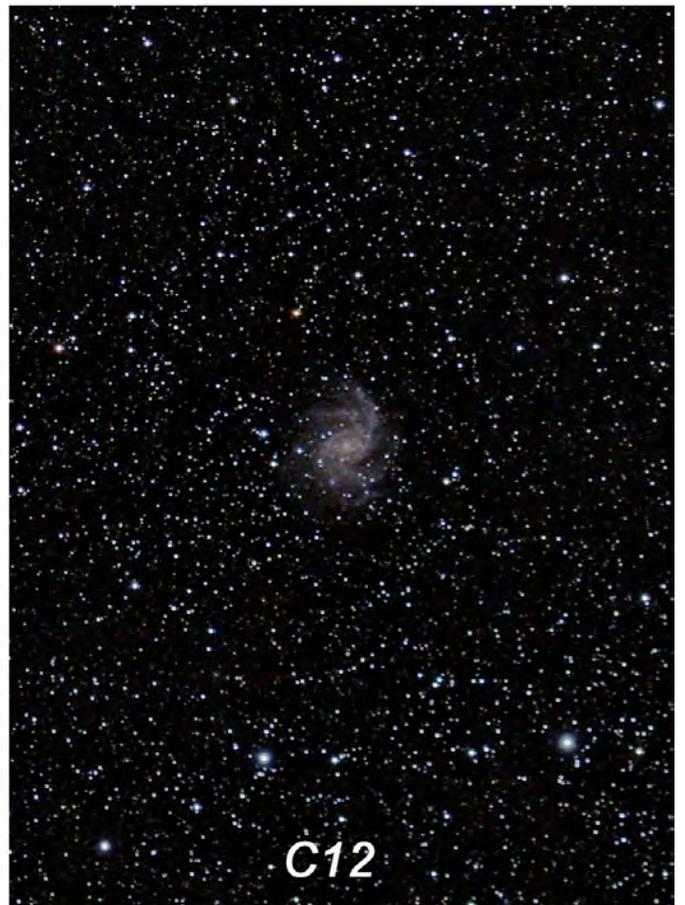
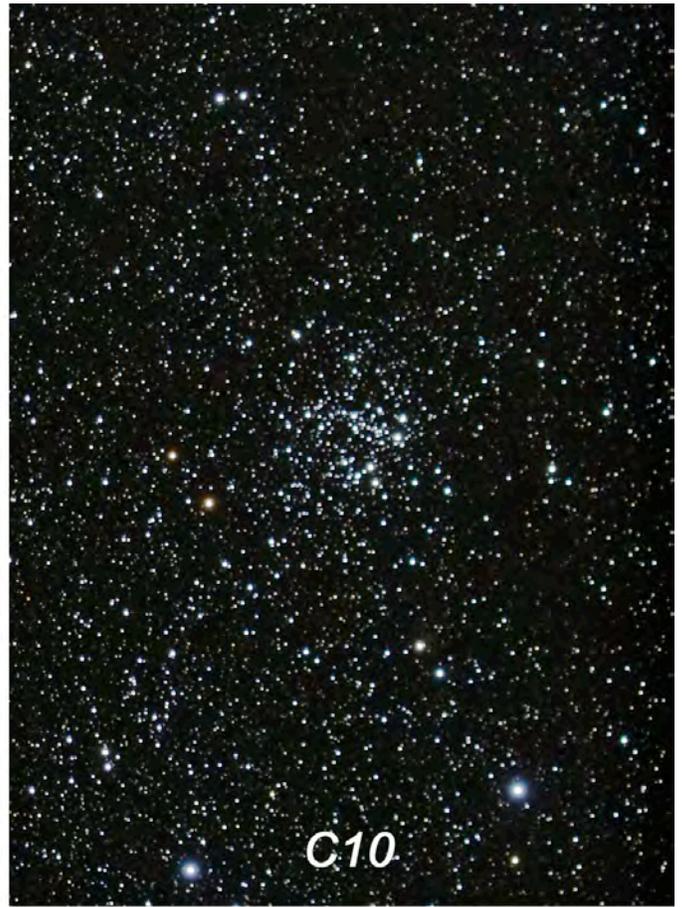
oc: open cluster pn: planetary nebula sg: spiral galaxy
gc: globular cluster bn: bright nebula eg: elliptical galaxy
sr: supernova remnant dn: dark nebula ig: irregular galaxy

A Canon 180mm B Canon 100-400mm C Sky 90

C	NGC	Type	Optics	C	NGC	Type	Optics	C	NGC	Type	Optics
1	188	oc	C	38	4565	sg	C	75	6124	oc	C
2	40	pn	C	39	2392	pn	C	76	6231	oc	B
3	4236	sg	C	40	3626	sg	C	77	5128	sg	C
4	7023	bn	C	41	Hyades	oc	A	78	6541	gc	C
5	IC342	sg	B	42	7006	gc	C	79	3201	gc	C
6	6543	pn	C	43	7814	sg	C	80	5139	gc	B
7	2403	sg	C	44	7479	sg	C	81	6352	gc	
8	559	oc	C	45	5248	sg	C	82	6193	oc	
9	Sh2-155	bn	C	46	2261	bn	C	83	4945	sg	
10	663	oc	C	47	6934	gc	C	84	5286	gc	
11	7635	bn	C	48	2775	sg	C	85	IC2391	oc	
12	6946	sg	C	49	2237	bn	C	86	6397	gc	
13	457	oc	C	50	2244	oc	C	87	1261	gc	
14	869/884	oc	C	51	IC1613	ig	C	88	5823	oc	
15	6826	pn	C	52	4697	eg	C	89	6087	oc	
16	7243	oc	C	53	3115	eg	C	90	2867	pn	
17	147	eg	C	54	2506	oc	C	91	3532	oc	
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23	891	sg	C	60	4038	sg	C	97	3766	oc	
24	1275	sg	C	61	4039	sg	C	98	4609	oc	
25	2419	gc	C	62	247	sg	C	99	Coal Sack	dn	
26	4244	sg	C	63	7293	pn	C	100	IC2944	oc	
27	6888	bn	C	64	2362	oc	C	101	6744	sg	
28	752	oc	C	65	253	sg	C	102	IC2602	oc	
29	5005	sg	C	66	5694	gc	C	103	2070	bn	
30	7331	sg	C	67	1097	sg	C	104	362	gc	
31	IC405	bn	C	68	6729	bn	C	105	4833	gc	
32	4631	sg	C	69	6302	pn	C	106	104	gc	
33	6992/5	sr	A	70	300	sg	C	107	6101	gc	
34	6960	sr	A	71	2477	oc	C	108	4372	gc	
35	4889	eg	C	72	55	sg	C	109	3195	pn	
36	4559	sg	C	73	1851	gc	C				
37	6885	oc	C	74	3132	pn	C				

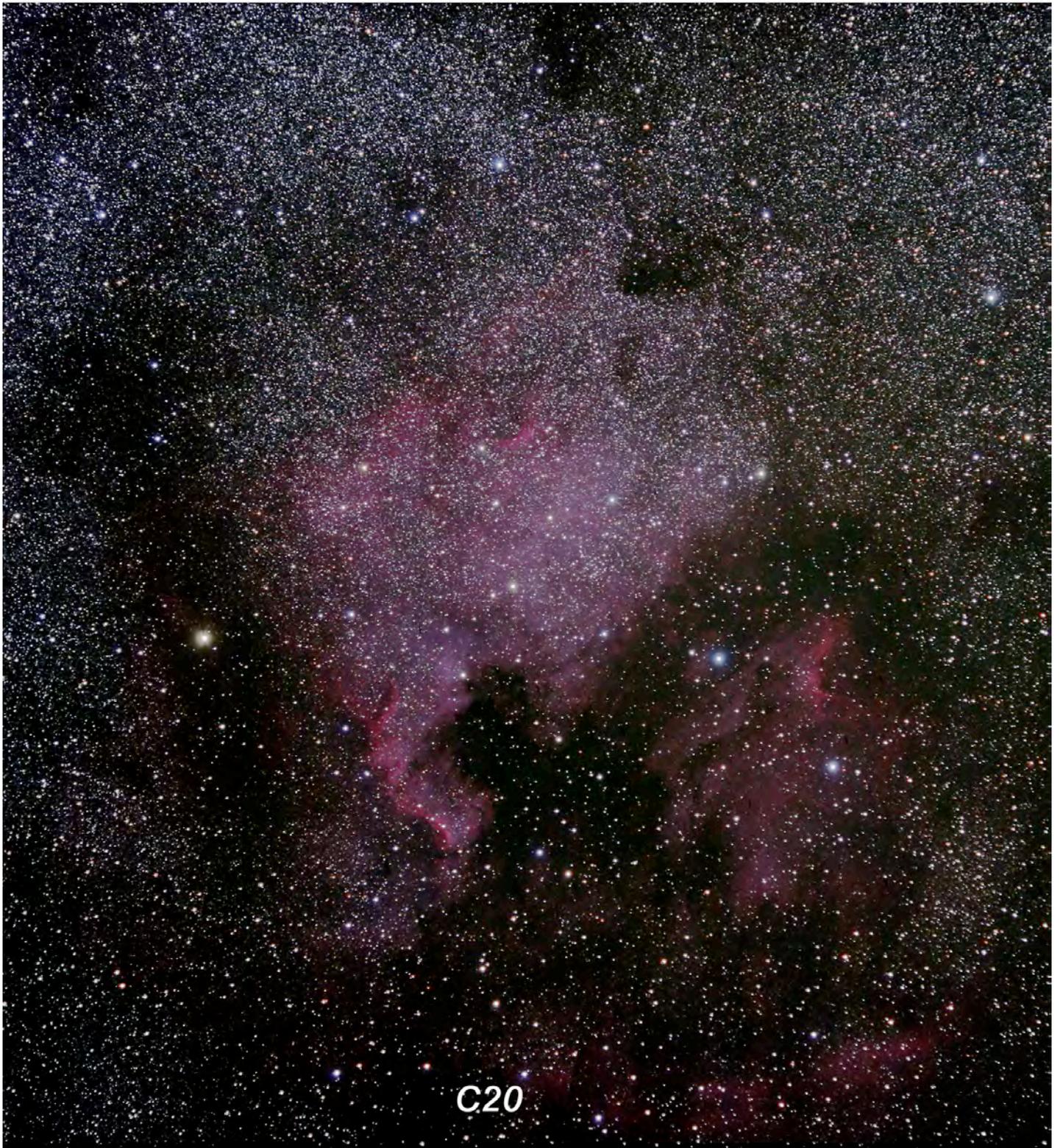




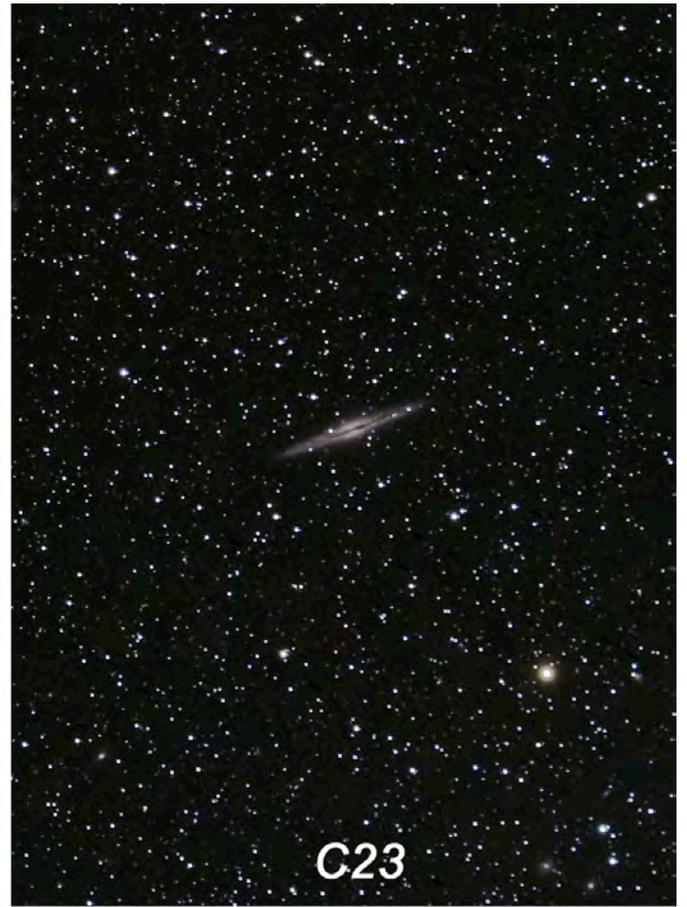








C20





C26



C27



C29



C30



C28



C31*



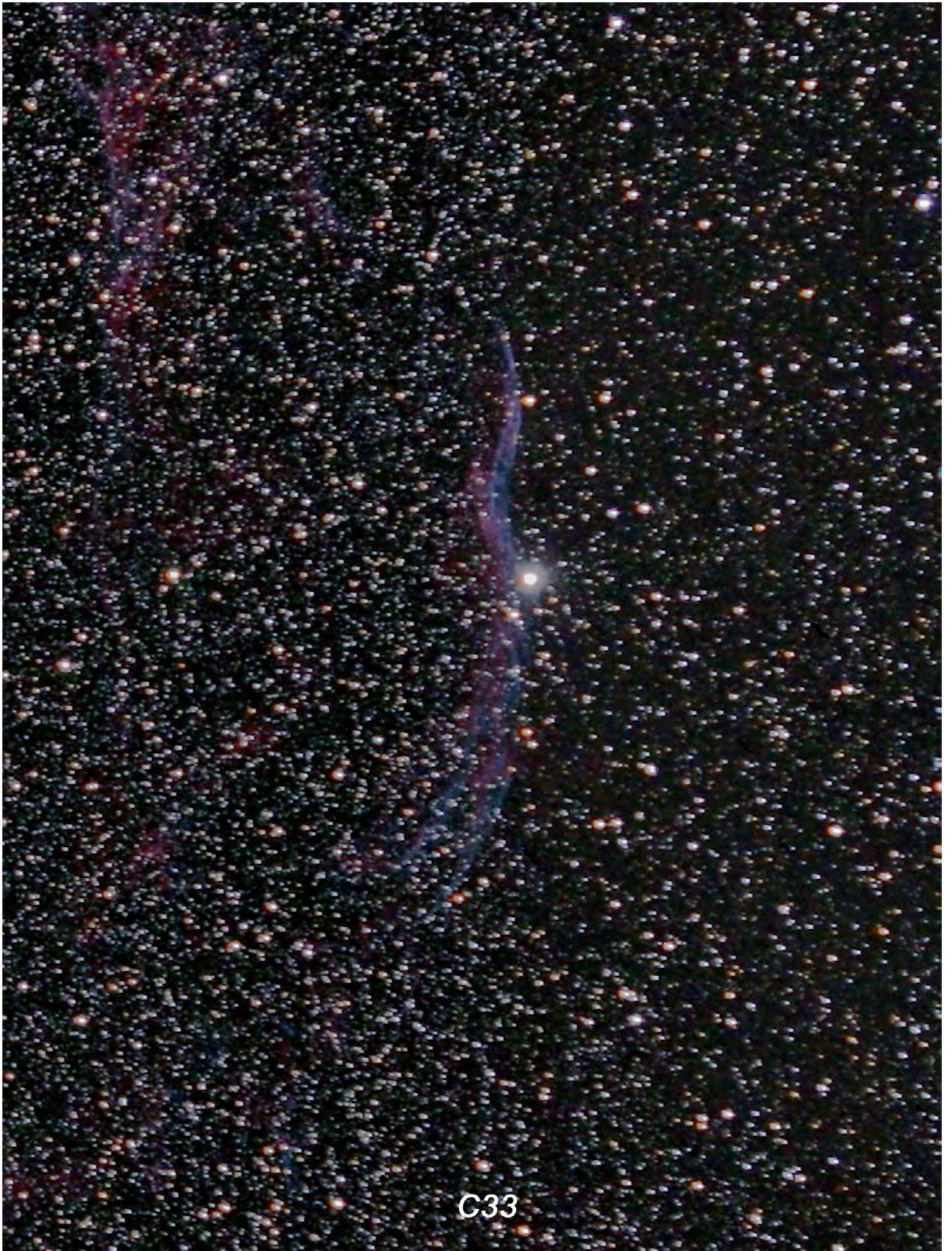
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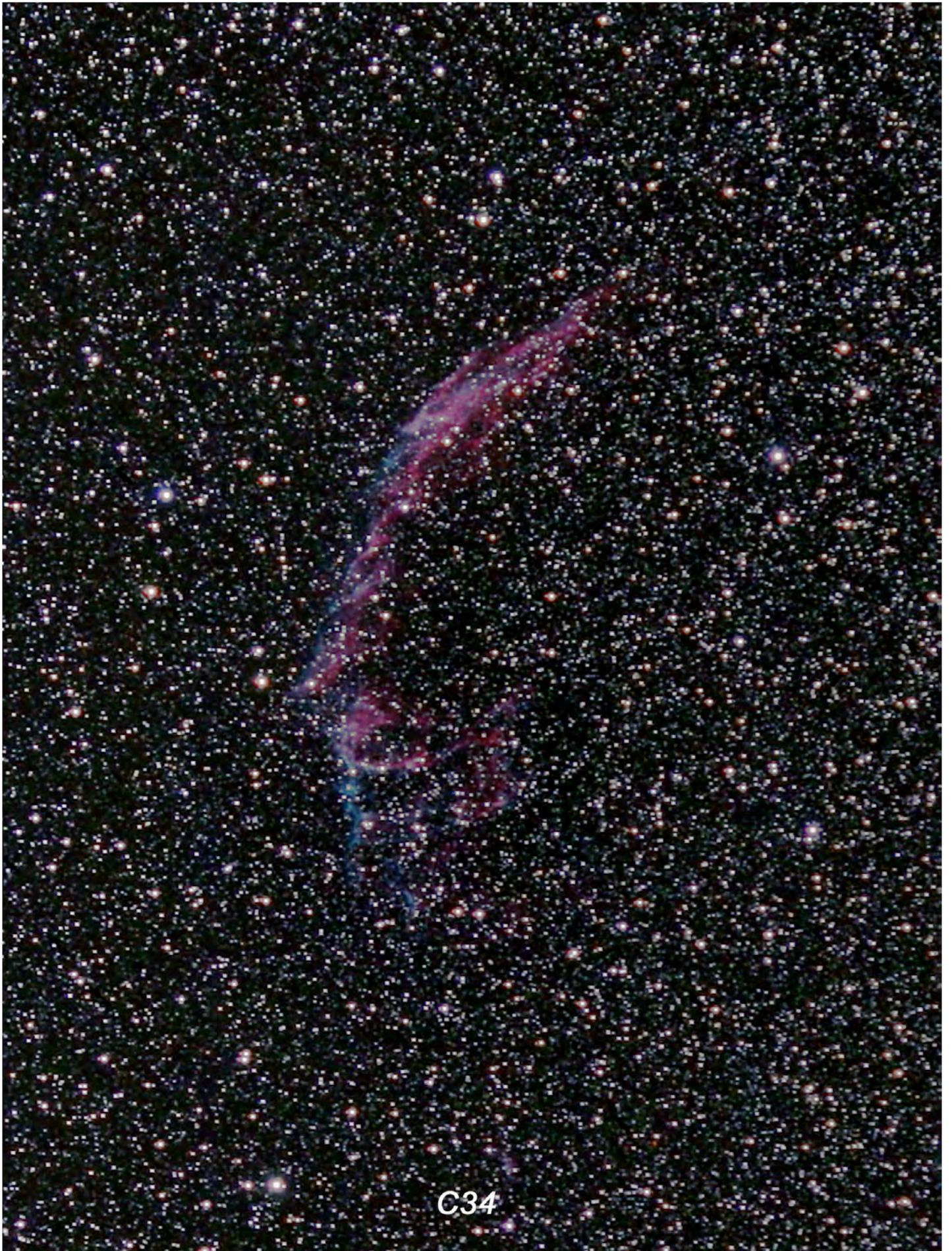
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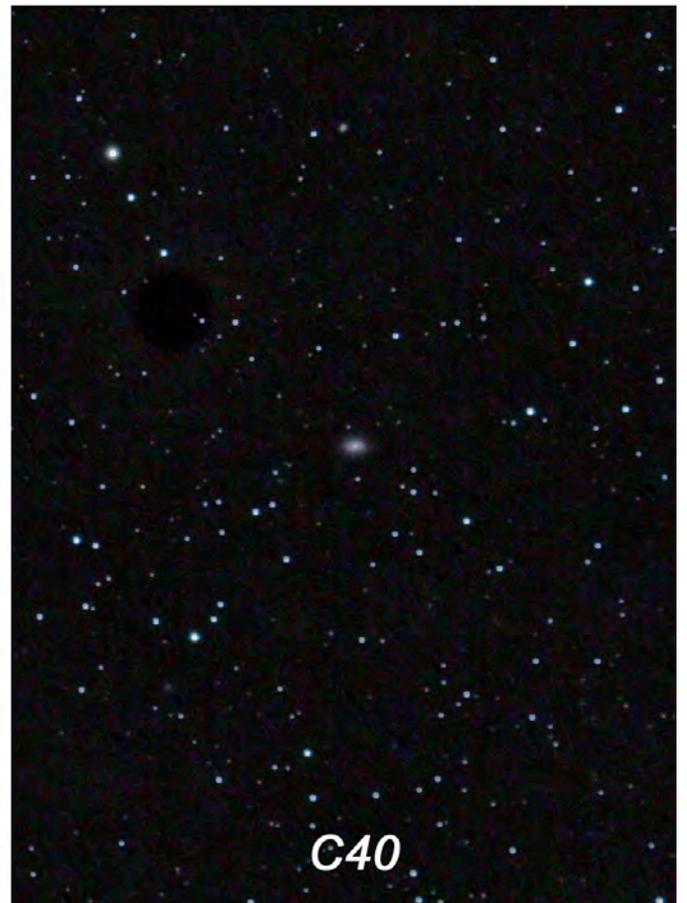
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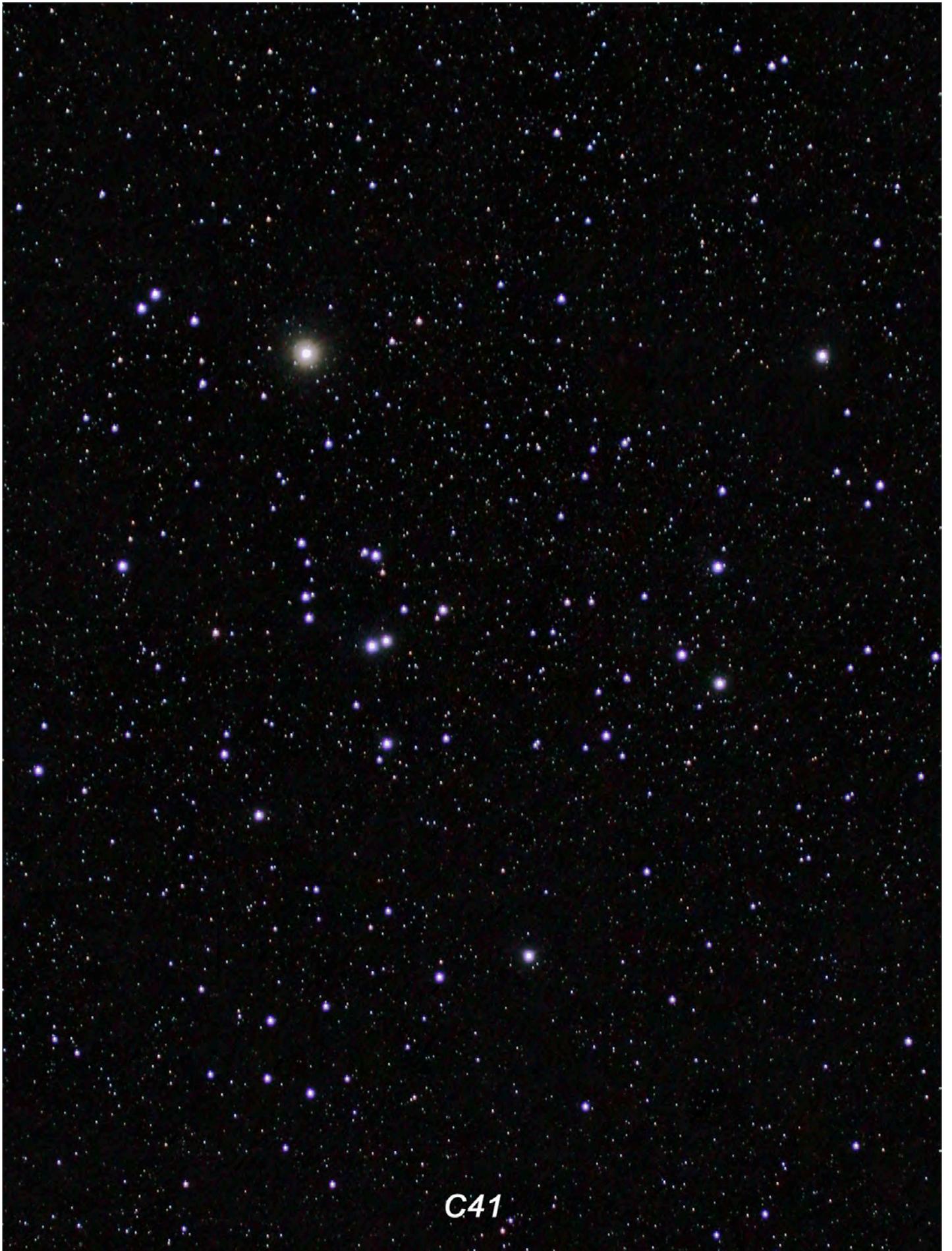


C33



C34

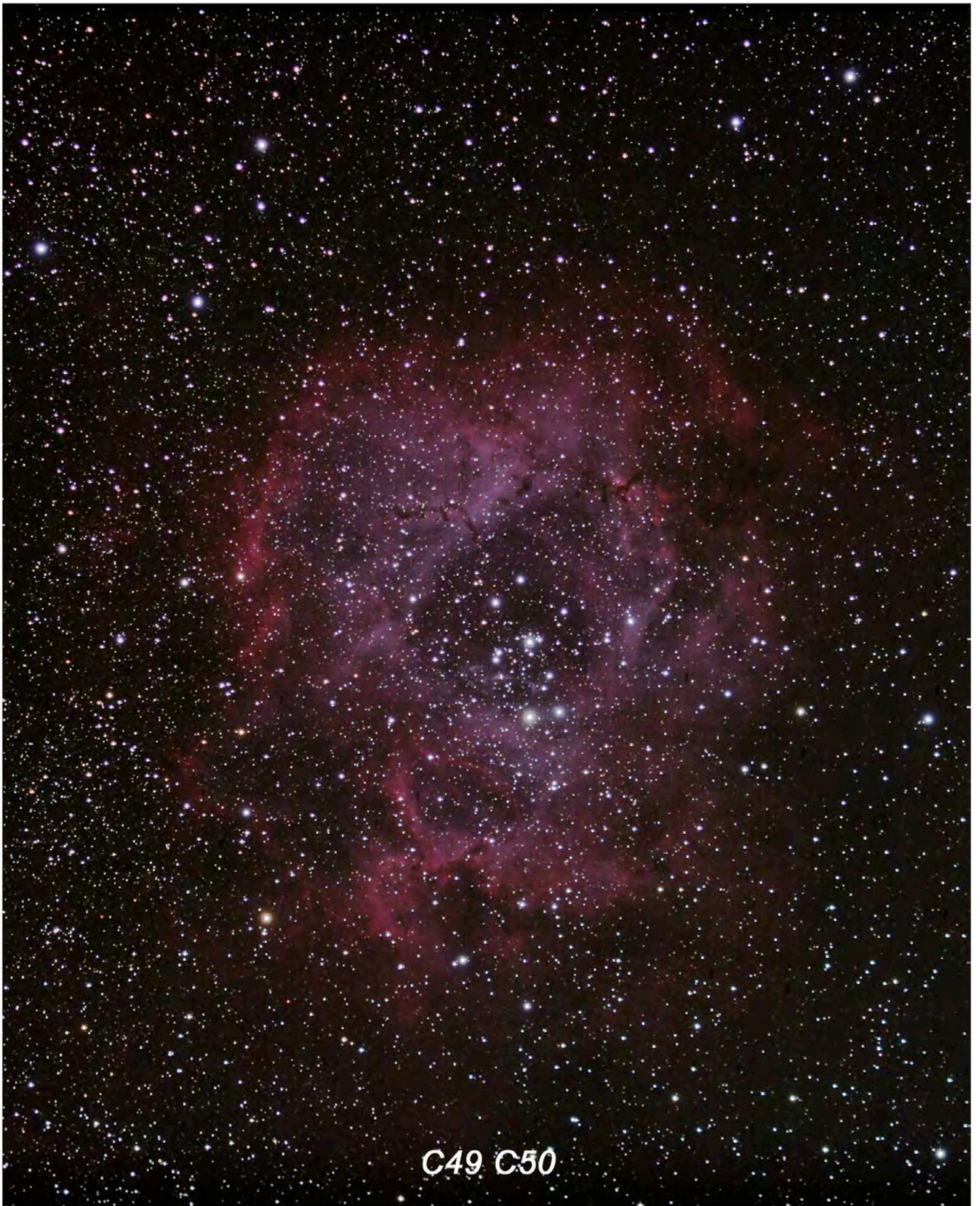




C41







C49 C50





C56



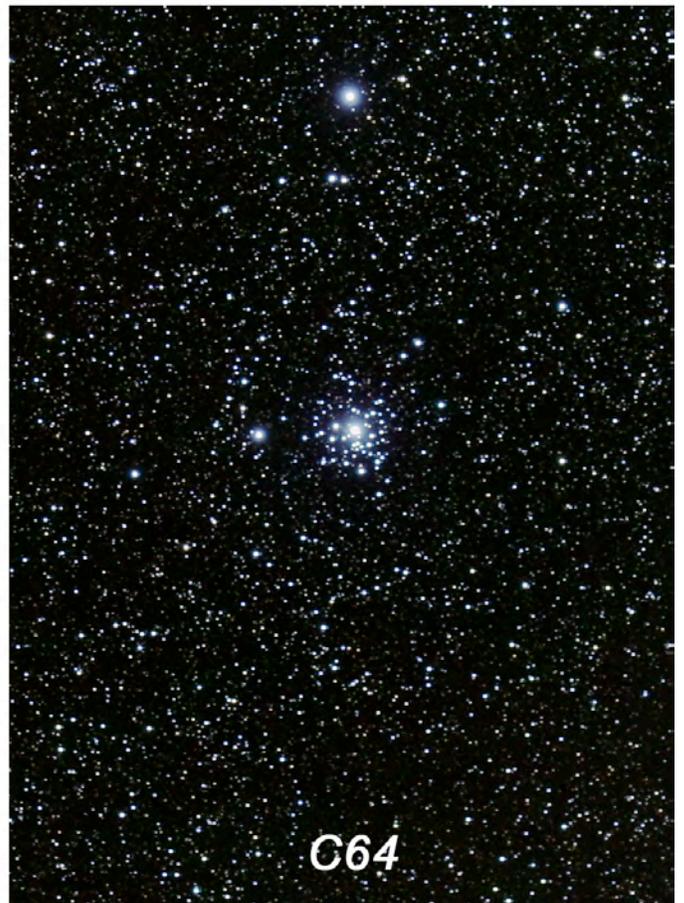
C57

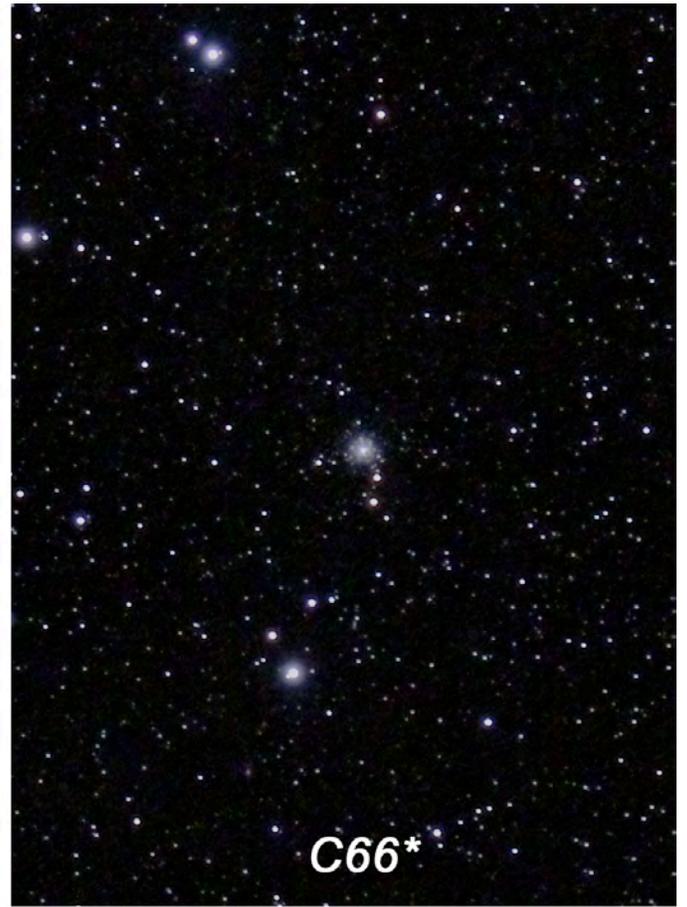


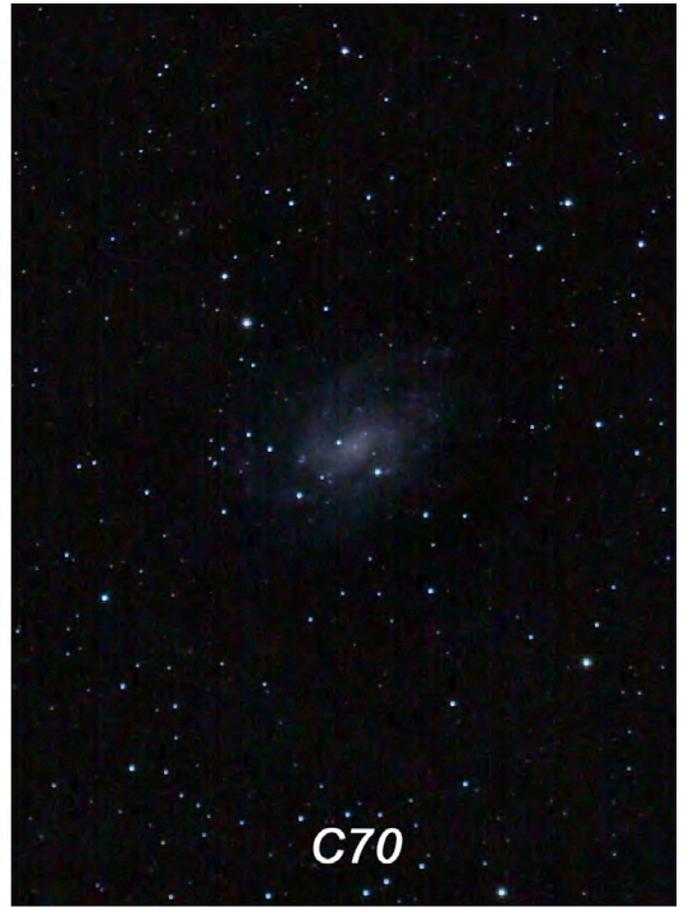
C58

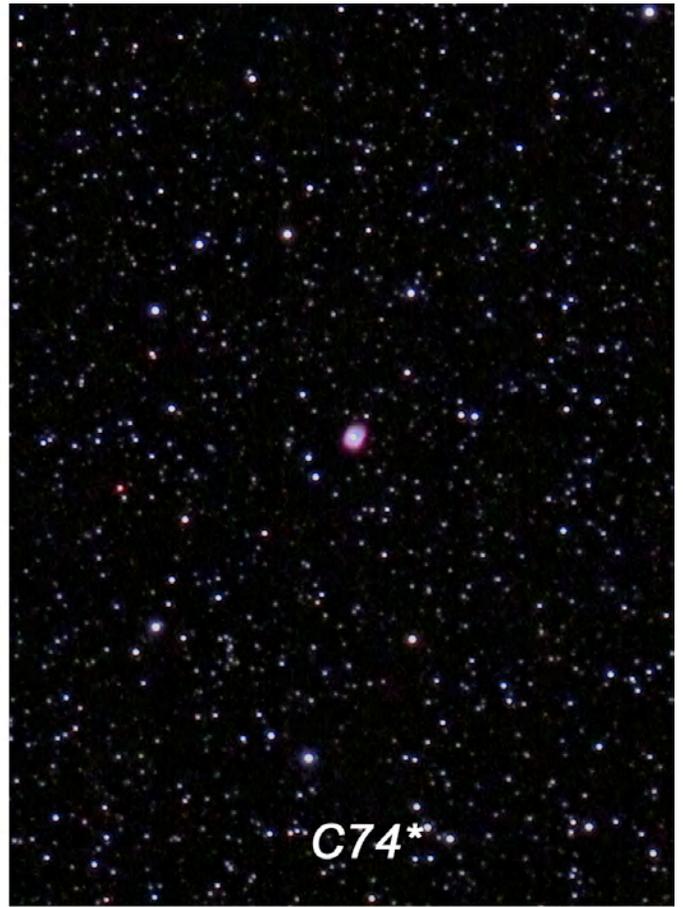


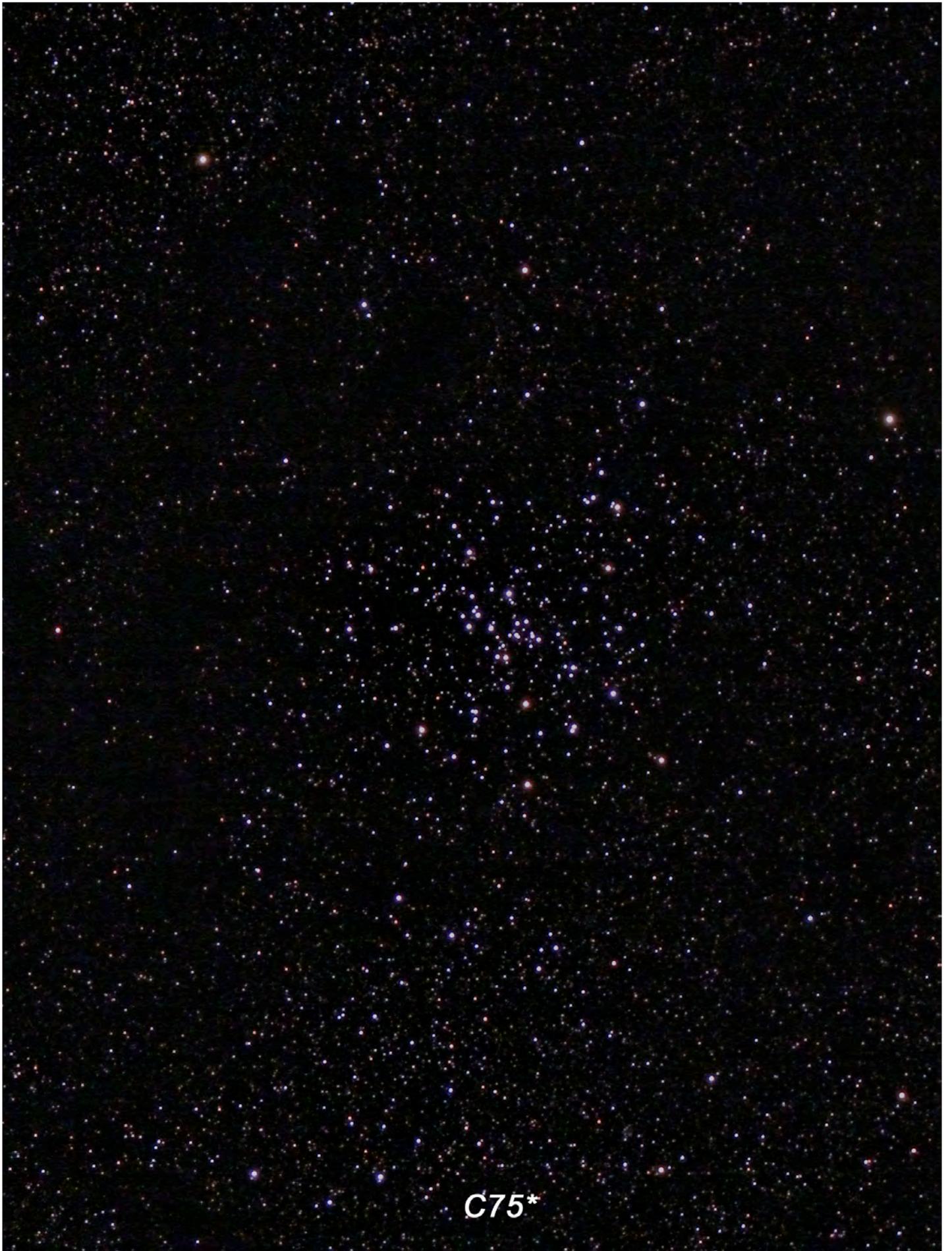
C59











C75*



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