Introduction

Comets are truly remarkable members of the solar system. Believed to be debris left from the solar system's creation, they are a link to understanding the composition and formation of the solar system. Described as 'dirty icebergs', a comet's nucleus is an agglomeration of ices (such as water, carbon dioxide, ammonia), dust and rock particles. As a comet approaches the inner solar system, heating from the sun causes the ices to vaporize, releasing the gases, dust and particles. Solar radiation pressure pushes the released materials away, creating the coma and tails that are the signature feature of a comet.

Comets are wonderful subjects for photography because they are very can rapidly change in appearance and are a beautiful example of the dynamic nature of the solar system. As they approach the sun, sudden increases in vaporization can release large chunks from the nucleus or create localized vapor jets, modifying the appearance of the coma and tail. Gravitational forces from close approaches to planets or the sun can break the nucleus into fragments, creating a multiple comet string. And severe interaction with the sun can cause the comet to completely vaporize and disappear.

This album presents photographs of comets from January 14, 2015 through March 24, 2020. The comets are:

- Lovejoy C/2014 Q2
- Tuttle-Giacobini-Kresak 41P
- Johnson C/2015 V2
- ASASSN1 C/2017 O1
- PanSTARRS C/2017 T2

All comets were photographed in Prescott Valley, Arizona, Lat: +34° 39' 08", Long: -112° 19' 20".
Equipment

- Canon EOS 60Da, 5184 x 3456 pixel CMOS, 17.9 Mpx
- Stellarvue SV80ST-25SV with SFFR80-25 field flattener - 480mm f/6
- Software Bisque Paramount MX equatorial mount on a permanent pier controlled by TheSkyX Pro and an Apple MacBook Pro laptop computer.
Software Bisque Paramount MX GEM
Focusing

Focus was achieved using a Bahtinov mask in front of the refractor objective lens by observing the Bahtinov diffraction pattern on the computer screen using Stack Labs' Nebulosity 3. Focus adjustments were made manually.

![Image showing focus comparison](image)

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 3200 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 camera’s memory card. 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 CS6. 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 8-12.
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.

Each group of photographs is proceeded by a brief description of the image details.
1) January 14, 2015; Star Registered
2) January 21, 2015; Comet Registered
3) March 10, 2015; Star Registered
4) March 10, 2015; Comet Registered
Tuttle-Giacobini-Kresak

41P

5) March 19, 2017; Star Registered

6) March 19, 2017; Comet Registered

7) March 20, 2017; Star Registered

8) March 20, 2017; Comet Registered

9) Composite of Images 5 & 7

10) Composite of Images 6 & 8
Johnson

C/2015 V2

11) May 19, 2017; Star Registered
12) May 19, 2017; Comet Registered
13) May 21, 2017; Star Registered
14) May 21, 2017; Comet Registered
15) Composite of Images 11 & 13
16) Composite of Images 12 & 14
17) May 25, 2017; Star Registered
18) May 25, 2017; Comet Registered
ASASSN1

C/2017 O1

19) October 16, 2017; Star Registered
20) October 16, 2017; Comet Registered
21) October 21, 2017; Star Registered
22) October 21, 2017; Comet Registered
23) October 21, 2017; 2.5 hours of comet movement
PanSTARRS

C/2019 T2

24) January 23, 2020; Star Registered
25) January 23, 2020; Comet Registered
26) January 25, 2020; Star Registered
27) January 27, 2020; Star Registered
28) January 27, 2020; Comet Registered
29) Composite of Images 24, 26 & 27
30) February 16, 2020; Star Registered
31) March 24, 2020; Comet Registered
32) April 15, 2020; Star Registered
33) April 15, 2020; Comet Registered