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Narrowband Observations of Comet 46P/Wirtanen with the Las Cumbres Observatory (LCO) Telescope Network

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Abstract

Comets are the material left over from the formation of the Solar System and research into them helps us understand the subsequent evolution. The nuclei of most active comets cannot be observed directly from Earth, and we must infer the properties from the gas and dust surrounding the nucleus. Observations of the evolution of this gas and dust coma over time allows connection to the nucleus. In December 2018, Comet 46P/Wirtanen made a historically close passage to the Earth with a closest approach distance of 30 lunar distances (12 million km) on Dec. 16, 2018. In order to capitalize on this rare opportunity to obtain high-resolution images of the inner coma from Earth, we rapidly built and deployed a new instrument to Las Cumbres Observatory's Faulkes Telescope North (FTN) 2-m telescope. This instrument was built and deployed in a few weeks, contains several narrowband filters tuned to cometary gas and dust emissions. We describe the development and commissioning of the instrument and use during the close approach of 46P.

1. Introduction

Comet 46P Wirtanen is a Jupiter family comet with a relatively small nucleus ($r \sim 0.6\,\text{km}$; [2]) and is also a member of the small family of hyperactive comets. These include 103P/Hartley 2, the target of the Deep Impact Extended Investigation (DIXI), and 21P/Giacobini-Zinner. 46P's water production rate is higher than expected, based only on its nucleus size and standard water vaporization models ([3]). Naively this would indicate that the whole of the comet's surface is active which is unrealistic. Instead, like Hartley 2, we expect that the nucleus contains hypervolatile ices that carry grains of water ice which sublimate at some distance from the nucleus, producing the apparent hyperactivity.

During December 2018, 46P made a historically close approach to the Earth (30 lunar distances) only a few days after perihelion. These observing conditions at the time of the Earth encounter were similar to a distant spacecraft flyby, with spatial resolutions as good as 57 km/arcsec. This allowed our studies to investigate the comet's innermost coma and see the evolving structure of the nucleus and inner coma. As 46P was near opposition around the time of close approach, it was visible for many hours per night for many weeks from both hemispheres. This allowed for extended detailed studies of the comet, the evolving activity and rapid reaction to and monitoring of any potential outbursts during the period as it moved into and away from perihelion. We describe the monitoring campaign using the narrowband and broadband filters in the CometCam instrument on the 2-m FTN telescope of the LCO robotic telescope network.

2. The Las Cumbres Observatory (LCO) Network

Las Cumbres Observatory (LCO) has now been operating a distributed robotic telescope network for five years. The telescope network consists of two 2-meter telescopes, one each at a site in each hemisphere, and a total of nine 1-meter and ten 0.4-meter telescopes at three sites in each hemisphere. Three more 1-meter telescopes will be added to the network in 2020-2021. The global coverage of the network and the telescope sizes available make the LCO network ideal for long term follow-up and characterization of a wide range of Solar System objects and in particular comets. The rapid response capabilities and telescope distribution also makes the LCO network ideal for responding to cometary outbursts and tracking their evolution.

2.1. Deployment of CometCam

In order to put the ESA filterset back into use after the original LCO camera which housed them suffered a power supply failure, a plan was developed in April 2018 to rehouse the existing e2v CCDs in a more modern housing with upgraded electronics. In early November 2018 it became evident that the vendor was not likely to complete the work in time and an alternate plan was needed. Due to the format of the ESA filters (50 mm round) being incompatible with the majority of the LCO instruments' filterwheels (75 mm square), a hybrid solution was devised.

Figure 1: CometCam filterwheel in the clean room at LCO headquarters. The ESA comet filters are the six thicker filters towards the top right of the image. Filters are 50mm diameter and the filterwheel is 300mm across.

A spare SBIG STX-16803 4096×4096 pixel CCD camera, which was available after the deployment of the LCO Sinistro 1-m imagers, was mated with a filterwheel from the LCO 0.4-m instruments (which also take 50 mm round filters). A custom mounting and adapter plate was fabricated at LCO allowing the instrument to be mounted to a sideport of the LCO 2-m Faulkes Telescope North (FTN) telescope. During this time, the filters were extracted from the original filterwheel and the transmissions were remeasured with a Cary/Agilent 5000 spectrophotometer. The filterwheel was populated with OH, C_2, NH_2, CN, C_3 and a red continuum filter from the ESA set and broadband Bessell B, V, R and Sloan g', r', i', z'_s filters.

Following assembly and bench testing of the filterwheel and camera at LCO under software control, the instrument was disassembled, packed and shipped to FTN in Maui, HI. There it was mounted on the telescope and commissioned on-sky under control from LCO HQ in Santa Barbara, CA.

3. Summary and Conclusions

We describe the construction of a new instrument, CometCam, that contains narrowband filters for cometary coma investigations and discuss its deployment to the robotic 2-m FTN telescope in Maui, HI. The instrument was used for the 46P monitoring campaign from 2018 November to 2019 May and the comet was observed on 46 separate nights and data analysis is ongoing.

In addition to CometCam observations of 46P, we have been using the LCO network to respond to comet and active asteroid outbursts, allowing us to provide time-critical follow-up on evolving comet outbursts (e.g [1], [4]). LCO has developed the TOM Toolkit[1], allowing the development of Target Observation Manager (TOM) systems to coordinate follow-up of targets across a range of facilities. LCO, along with NOAO, SOAR & Gemini, is also developing AEON[2], the Astronomical Event Observatory Network, which will allow programmatic rapid response access to larger telescope facilities such as the SOAR 4.1-m and eventually the Gemini 8-m telescopes. This combination of robotic facilities with varied instrumentation will make a powerful network for studying many aspects of comet behavior and evolution.

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[1] https://tomtoolkit.github.io/
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