

Hubble Pi



Santiago Rodriguez

A seminar at Berlin Humboldt University introduced 21-year-old Spaniard Santiago to coding in Python for numerical physics, and kick-started his first ever Raspberry Pi project.

magpi.cc/hubblepigit

A 'Eureka!' moment at university led one student to retrofit his telescope with an HQ Camera sensor and aim it at the stars. **Rosie Hattersley** learns more

When physics student **Santiago Rodriguez** learned about the possibilities of Python for numerical physics, he immediately recalled a conversation with a friend about a new product from Raspberry Pi, the **High Quality Camera**.

This camera would work with Santiago's beloved, but rather small, Maksutov telescope. Having been a huge fan since childhood of all things space-related, and with plans to study astrophysics and masters and PhD level, he suddenly saw how coding might just fit in... and the idea for Hubble Pi was born.

Santiago's goal was to use a Raspberry Pi 4 and HQ Camera to take pictures with his telescope of planets, stars, and maybe even DSOs (deep-sky objects). He also decided to load his Raspberry Pi with established astronomy programs such as KStars, which can display a live map of the night sky directly on the telescope using an attached display.

Magic mirror lens

He realised that the HQ Camera's "bigger, exposed sensor would allow it to essentially use the telescope as a big mirror lens. It was quite cheap for the quality it could offer." For controlling the sensor for astrophotography, the flexible, open-source nature of Raspberry Pi appealed too.

“ He began by learning what the sensor could do from the HQ Camera documentation ”

To achieve this, Santiago developed AstroCam, a Python GUI for controlling the camera for astrophotography. "Using it, I can control ISO, shutter speed, and exposure time (with some limitations due to the digital nature of the rolling shutter)," he explains.

AstroCam can also take multiple exposures automatically, and capture RAW image files – both important capabilities for astrophotography.



◀ Astronomy programs such as KStars can be installed on Raspberry Pi to provide a map of the night sky



Hubble Pi features a Raspberry Pi 4 and a touchscreen from which image capture can be triggered. The setup can also be accessed using a remote desktop connection

The photos taken of the night sky with Raspberry Pi's HQ Camera are comparable to those captured using a DSLR camera with the telescope rig

The HQ Camera and the telescope's optics work really well together, with a readily available C-mount-to-telescope adapter connecting them seamlessly

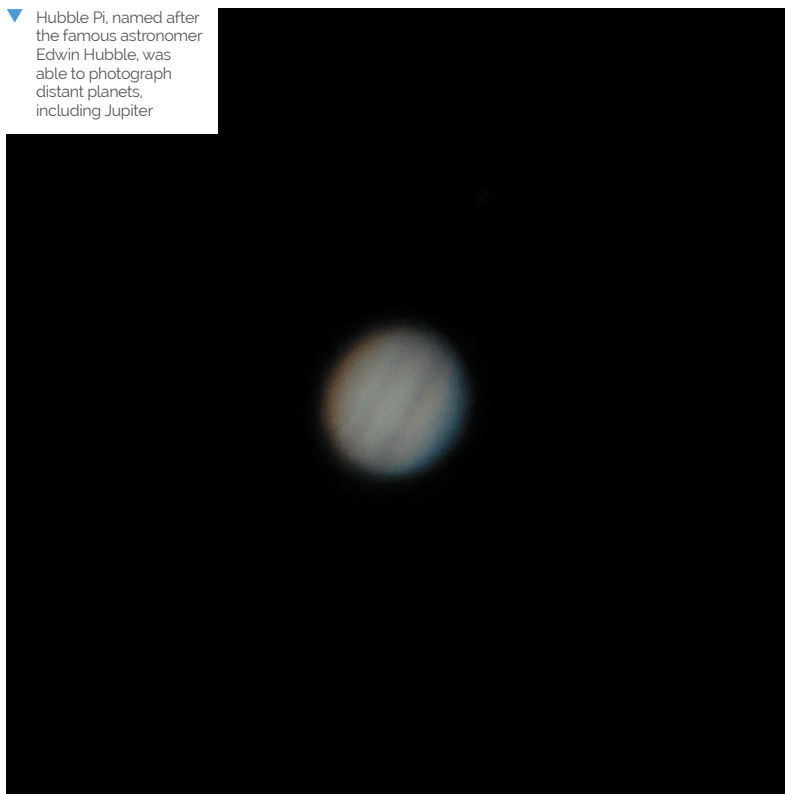
Quick FACTS

- ▶ Santiago set up his astro camera pointing out the window
- ▶ His friends thought he was spying on his neighbours
- ▶ Pointing the telescope at the sun without covers was another howler
- ▶ But he does recommend sharing your live photos with friends
- ▶ And even recommends it as a conversation starter



▲ The Hubble Pi setup captured fantastic close-ups of the moon, including this one showing Mare Crisium

▼ Hubble Pi, named after the famous astronomer Edwin Hubble, was able to photograph distant planets, including Jupiter



“ Hubble Pi can also work wirelessly or as a standalone if needs be ”

Controls are triggered locally via a touchscreen, or through a remote desktop connection from a laptop connected via Ethernet or a wireless LAN hotspot hosted by Raspberry Pi. He was reasonably confident the project would work, having seen similar endeavours based around Raspberry Pi 3B.

Santiago had never used Python before, so he began by learning what the sensor could do from the HQ Camera documentation, after which the main challenge was coding the GUI program with Tkinter and adapting it for his astrophotography needs. “I based my AstroCam script’s main loop and the image preview code on that of a Python programmer who had developed it for a normal camera use,” he says. The source is credited in the documentation in Santiago’s GitHub repository: magpi.cc/hubblepigitt.

Although others had posted similar projects on GitHub, no one had written about using the C-mount adapter for the HQ Camera for astrophotography at the time. Fortunately,



C-mount-to-telescope adapters are fairly common, and Raspberry Pi itself could simply be mounted using a simple phone adapter.

▲ Another moon shot, showing Crater Tycho and Mare Nubium

Shooting stars

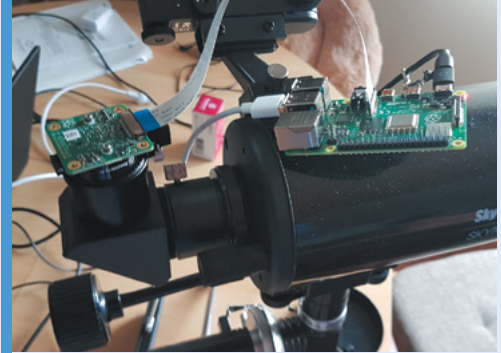
Santiago is reasonably pleased with the results from Hubble Pi. “Most good USB cameras for astrophotography start at about €200 and require a connected computer at all times. Hubble Pi can also work wirelessly or as a standalone if needs be,” he notes.

Raspberry Pi 4 and HQ Camera sensor work very well, but photos are limited by the optical limitations of his telescope, while humidity and light pollution are also factors. “Planets and stars look alright, but somewhat blurry without stacking (due to atmospheric distortion), and DSOs are very difficult to capture due to the f/14 aperture ratio from the small Maksutov (brighter/bigger optics should deliver better results here),” discloses Santiago.

“My friend’s DSLR doesn’t perform much better when attached to my telescope at prime focus,” he says. “The only real limitation from the sensor side of things is its digital rolling shutter, which means it can’t do hour-long exposures like DSLRs.” But an expensive star tracker (to compensate for the drift during the lengthy exposure) costs upwards of €300.

When finances allow, Santiago intends to develop Hubble Pi in this direction. For now, he’s pretty pleased with his first Raspberry Pi project. “This may have been the first, but it certainly won’t be the last!” **M**

Assemble your rig



- 01** You need a Raspberry Pi 3 or 4 with 2GB+, a touchscreen display, and a 32GB microSD card, plus an HQ Camera (sensor only), telescope, and 1.25-inch C-mount adapter. Power from a USB-C or a USB power bank.



- 02** Create a `wpa_supplicant.conf` file and empty `ssh` file in Raspberry Pi’s boot directory (instructions at magpi.cc/headless) so you can access Hubble Pi directly from a computer. For remote connections, use XRDP or a monitor and keyboard-mouse combination.



- 03** Connect your HQ Camera and enable the camera (see magpi.cc/picamera2), then mount the telescope and take some test shots by typing `raspistill -o Desktop/image.jpg` into a Terminal.