

The Blue Lizard Telescope controller

Wolfgang Birkfellner, wbirkfellner@gmail.com

April 18, 2022

1 Hardware and Functionality

Blue Lizard is a telescope controller for driving bipolar stepper motors connected to equatorial telescope mounts. It is capable of providing up to 3.0 A current per coil and its resolution can be set as low as $\frac{1}{128}$ microsteps. The main interaction with peripheral software such as planetarium programs takes place via WLAN. Blue Lizard either spawns a WLAN of its own or it can be integrated into an existing network infrastructure. It supports communication with SkySafari¹ on Android or iOS operating systems for tablets, but it can also communicate via INDI² and ASCOM³. The basic command set is a subset of the well-known LX200 protocol. Blue Lizard also supports guiding commands via ST4, and it features compact handbox. For telescope control via ASCOM, a dedicated USB interface translating the commands from the *Advanced LX200 ASCOM Driver*⁴ to the wireless interface of Blue Lizard is available. Internally, the Blue Lizard controller is powered by a Raspberry Pi microcomputer and an ARM Cortex-M4 microcontroller running at 180 MHz. In addition, date and time are stored in an internal high precision clock.

2 Setting things up

After connecting a sufficient power source providing 12 V, Blue Lizard can be turned on using the **On/Off** button (marked **b** in Fig. 1). As the Raspberry Pi microcomputer has to boot, it might take up to 20 seconds until the front display shows operation. A beep is heard when Blue Lizard is ready. Initially, the display shows the date and time as

¹ www.skysafariastronomy.com

² www.indilib.org

³ www.ascom-standards.org

⁴ www.pixeltelescopes.wordpress.com/advanced-lx200



Figure 1: Back panel of Blue Lizard. **a** denotes the power insert for a minimum operating voltage of 12 V DC, **b** is the power switch and **c** is the momentary switch for shutting or rebooting Blue Lizard. **d** is the ST4 port, which either processes input from an autoguiding system such as the Lacerta MGEN or a handbox. **e** and **f** are a USB-to-Serial (for ASCOM) and RJ45 interface to the Raspberry Pi. **g** is an LED that is lit when the system is powered up.



Figure 2: After starting up the controller, the system time and date as stored by the internal clock of Blue Lizard are displayed, together with the preferred communication method for displaying the position of the telescope on a planetarium program, cell phone or tablet.

stored in the internal real-time clock, and the chosen method of communication with external software (Fig. 2). At this stage, one can now start to connect to the internal webserver of Blue Lizard and the controller can be parametrized.

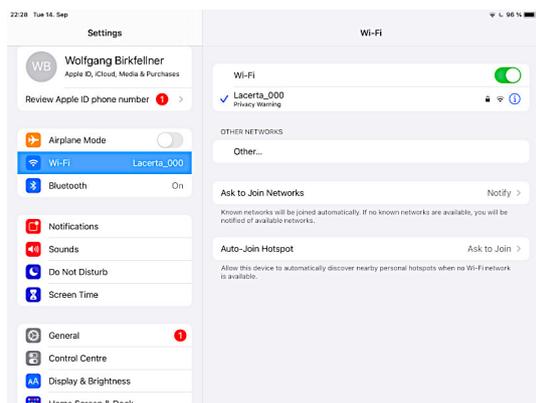


Figure 3: Selection of the wireless access point of the Blue Lizard controller. By default, the name is **Lacerta_xxx**, where **xxx** is the serial number of your personal device. The default password is *Lacertaxxx* without the ”_” character.

In order to connect to the webserver of Blue Lizard, one needs to locate the internal WLAN access point; per default, this is **Lacerta_xxx**, where **xxx** is the serial number of your controller. Fig. 3 shows this selection process on an iPad. On a conventional computer, one simply has to connect to this WLAN access point. The default password is **Lacertaxxx** without the ”_” character. If your controller reads, for instance, *22_012* as the serial number, the password is *Lacerta012*. Once you have connected, you can start any web browser and type the IP address of the controller, which is by default **192.168.4.1**. Fig. 4 shows the resulting screen.

2.1 The telescope parameter settings

- **Observatory Name:** This is just an arbitrary name for your controller. Any combination of letters is fine here.
- **Longitude and Latitude:** Your current position. In Sect. 4, we will learn of an automated way to set this position by using *SkySafari*.

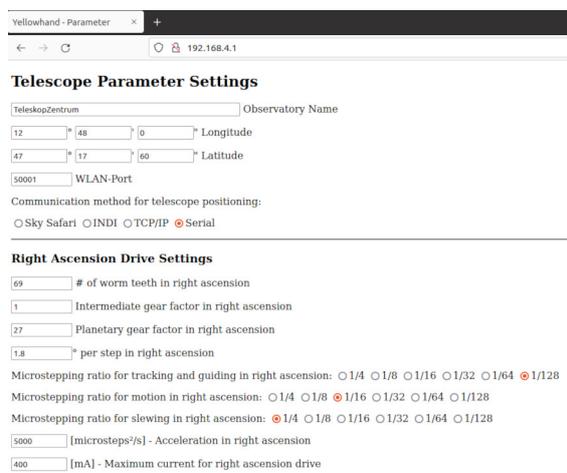


Figure 4: View of the configuration screen; after connecting your computer to the WLAN access point of Blue Lizard, one can open a web browser and type the default address **192.168.4.1** of the controller into the address line. The configuration details are explained in the text.

- **WLAN-Port:** The network port to connect to. The default port *50001* is fine and there is no obvious reason to change it.
- **Communication method for telescope positioning:** Here we have several choices; **Sky Safari** needs to be checked if *SkySafari* is to be used as the main display for showing the telescope position. **INDI** starts an INDI server that handles the simple LX200 commands for synchronizing, slewing and manual positioning of the scope. The well known programs *Stellarium*⁵ and *KStars* – which is well known from the *Astroberry*⁶ distribution – are examples of programs that support communication over this protocol. The option **TCP/IP** allows communication directly over the WLAN. *KStars* supports the LX200 protocol directly via TCP/IP. As you may have noticed, Blue Lizard has very little display capabilities of its own – it is designed to use a planetarium program for interaction. Details about connecting various programs are found in Sect. 3. **Serial** connects to the internal USB-to-Serial

⁵www.stellarium.org

⁶www.astroberry.io

converter of Blue Lizard; users of ASCOM will find an emulated COM-Port here.

2.2 Right Ascension Drive Settings

- **# of worm teeth in right ascension:** The number of teeth on your right ascension worm wheel. If you have a different drive, for instance a friction drive, you can set this value to 1.
- **Intermediate gear factor in right ascension:** If you have, for instance, a belt drive which adds a reduction factor, you should set this factor here. In a friction drive, you can also set the ratio of the diameters for the driver and the roller wheel there. If no intermediate gear is used, set this value to 1.
- **Planetary gear factor in right ascension:** Here, you can add an additional gear factor for a planetary drive that is connected to your stepper. If you do not have a planetary gear connected, set this value to 1.
- **°per step in right ascension:** This is the rotation of your stepper for a full step. 200 steps (or 1.8°) are a very common measure.
- **Microstepping ratio for tracking and guiding in right ascension:** The controller can move the stepper with utmost precision. At highest resolution, the 1.8° full step is subdivided into 128 microsteps, resulting in a discrete motion of only 0.85 minutes of arc. This is a useful mode for fine motion, but as the speed of the motor is limited, it makes no sense to use such a fine resolution for every motion. Here we recommend to go for the $\frac{1}{128}$ resolution.
- **Microstepping ratio for motion in right ascension:** *Motion* in this case refers to moves which are controlled via the handboxes. Blue Lizard knows four speeds, which are multiples of the sidereal motion; here, we talk about the intermediate level. $\frac{1}{16}$ is often fine in this case, but it can be set to a smaller or higher value.
- **Microstepping ratio for slewing in right ascension:** This is the microstepping ratio for

the fastest mode when the telescope is positioned. We use the rather coarse $\frac{1}{4}$ microstepping ratio in this case.

- **[microsteps²/s] - Acceleration in right ascension:** Due to inertia, a motor cannot immediately jump from rest to a desired speed. This would require an infinite acceleration value and therefore infinite force and current. A defined acceleration helps to precisely reach the desired speed while keeping the power consumption within limits. A value between 5000 and 10000 $\frac{\text{microsteps}^2}{\text{second}}$ is usually chosen. Too high an acceleration leads to step losses and even a stop of the motor.
- **[mA] - Maximum current for right ascension drives:** Setting the optimum coil current is crucial for precise action. The maximum coil current for the motor is given in its specifications. A rule of thumb says that one may start with 70% of this value. If your maximum coil current is, for instance, 1.5 Ampere, you can start with 1000 [mA]. If the motors get hot after a while or if they are very noisy, you may reduce this value. If you drive loses steps – this leads to an intermediate irregular noise especially at higher speeds after the acceleration phase, or if the drive does not move at all, your current is too low.

The procedure is the same for the declination drive. A well set motor is very silent, does not loose steps or stops at higher speeds (this behaviour is also called *stalling*) – it just moves your scope smoothly. The power available to the drivers is considerable – we have driven telescopes with a moving mass of 300 kg with NEMA 23 motors connected to a 1:9 planetary drive, a worm wheel of 288 teeth and a motor current of 1.5 [A].

2.3 Holding current and general drive settings

- **Holding current:** This is the fraction of the coil current supplied to the motor if the drive is stopped. In microstepping mode, it might happen that a motor drained of all power might snap into a convenient state – usually the next full step. In order to provide maximum accuracy in small movements – like guiding – it is

Holding Current
 Fraction of maximum motor current for holding current

General Drive Settings
 Fraction of sidereal speed for guiding
 Multiple of sidereal speed for handbox motion
 Multiple of sidereal speed for slewing

Meridian Flip Settings
 Meridian flip is off?
 ° - Maximum declination where no meridian flip for GEM is triggered.

Park Position Settings
 Go to parking position at shutdown?
 Parking Positions
 ° - Hour angle for parking position
 ° - Declination for parking position

Invert Mount Direction Settings
 Invert Right Ascension direction?
 Invert Declination direction?

Figure 5: The second part of the configuration screen shown in Fig. 4. The settings are explained in the text.

necessary to power up the motor at rest. However, it makes sense to reduce this current to a fraction of the current needed to move the drive. This is the holding current. Here, one can set the fraction of the maximum current for holding a drive.

- **Fraction of sidereal speed for guiding:** Guiding in astrophotography refers to subtle movements for correcting mechanical imperfections of the mount. It makes sense to carry out these movements in a fraction of the sidereal speed. Any value greater than 0 and below or equal to 1 is fine. *Do not forget to provide this ratio to your guiding software/hardware as well!*
- **Multiple of sidereal speed for handbox motion:** The protocol for sending commands to Blue Lizard – the Meade LX200 protocol – knows 4 different speeds. Two of them are slow – the base speed (usually the speed necessary to track the motion of the stars, the *sidereal speed*) and a fraction of it, the *guiding speed*. There are also two faster speeds available. *Handbox motion* is the speed that is set here; it is a multiple of the sidereal speed that

allows a comfortable tracking of motion in your favourite eyepiece.

- **Multiple of sidereal speed for slewing:** This is the maximum speed available – it is used for positioning your scope to celestial objects. Again, the factor set as a multiple of the sidereal speed.

2.4 Meridian flip settings

Here, we are dealing with a complex matter; users of German Equatorial Mounts (GEMs) like the Fornax or SkyWatcher mounts need to read this section carefully. Users of fork mounts or bent knee tripods may simply turn the meridian flip off.

- **Meridian flip is off?** Check this option if your mount is not a GEM and does not need to carry out a meridian flip. A GEM has two possible positions when looking at the south horizon; the scope can be *east of pier* or *west of pier*. In both situations, we look at the same position. When moving your scope, it might happen that the shortest path is not feasible as it would cause a crash of the eyepiece into the pier or tripod. Thus, it is necessary to carry out a *meridian flip* – the scope moves up to the celestial north (or south) pole and moves back to the declination of the object desired. The right ascension axis does also not move for a desired amount of degrees Δ , but by $360^\circ - \Delta$. After a meridian flip, the image on the eyepiece or on the sensor is rotated by 180° .
- **Maximum declination where no meridian flip for GEM is triggered:** At low declinations, for instance when following the horizon from southeast to southwest, a meridian flip may be unnecessary as the eyepiece never gets close to the pier (or tripod). If you are insecure about this, set this value to the minimum declination that can be reached from your observing site.

2.5 Park Position Settings

Blue Lizard features a small computer. A proper shutdown sequence is to be instantiated by pressing the **Shutd.** button (**c** if Fig. 1) for 2 or 5 seconds. If this routine is instantiated, you can tell

your mount to go to a defined position – this is the *Park Position*.

- **Go to parking position at shutdown:** If you uncheck this, the mount will simply stop at its current position and Blue Lizard will cease operation.
- **Parking positions:** A number of predefined positions can be chosen; these are:
 - **Southern Horizon:** The south horizon as visible from your position.
 - **Eastern Horizon:** The East horizon.
 - **Western Horizon:** The West horizon.
 - **Zenith:** The zenith – your scope point straight up into the heavens.
 - **Nadir:** The same as zenith if you are on the southern hemisphere.
 - **Northern Celestial Pole:** The position of Polaris – probably a classical position for a GEM.
 - **Southern Celestial Pole:** The same classical GEM position if you are on the southern hemisphere.
 - **Entered values below:** A custom position entered in the following text fields.
- **Hour angle for parking position:** If a custom position is chosen by selecting *Entered values below*: in the selection, this is the desired hour angle for the parking position.
- **Declination for parking position:** Same as above – the declination for a custom parking position.

2.6 Invert Mount Direction Settings

A bipolar stepper motor has four relevant wires; often, these are given as Green-Black and Red-Blue pairs. These are the four relevant leads. There may be more, but these are not relevant here. The wire pairs are denoted as A-A' and B-B' and they denote the leads to the two coils of the drive. If the relative resistance between two wires is close to zero, they belong to the same coil. Otherwise, the resistance is infinite. By permutating the wires, one can change the default rotation direction of the stepper drive. Or it can be done here.

- **Invert Right Ascension direction?:** Inverts the default direction of the right ascension drive. This may also be necessary if you move from one hemisphere to the other – e. g. when going from Europe to an African or Latin American country located south of the equator.
- **Invert Declination direction?:** Inverts the default direction of the declination drive.

Denote that the direction in declination can also be inverted if the initial position of a GEM concerning West-of-Pier/Right-of-Pier is given in the wrong fashion – more on this in Sect. 6.

2.7 Check your settings

After setting everything up, it is necessary to convey the data to the software – this is done by pushing the *Submit Query* button visible in Fig. 5. After that, the settings can be checked in the next browser page as shown in Fig. 6. Now it is necessary to restart the controller software. This can be done via the *Shutdown* button in the browser as shown in Fig. 6. But in this case, the WLAN connection is lost, and one has to reboot Blue Lizard completely. A more elegant version of reset and shutdown is described in Sect. 2.8.

2.8 Shutdown or restart using the Shud. – Button

As you may know, it is not recommended to shut down your computer by simply turning off the power – rather than that, a shutdown has to be instantiated. As Blue Lizard features a computer as its main element, we also need to shut it down properly, but as we do not have a keyboard connected, this can be done in a different way using the Shud. button, denoted as c in Fig. 1.

- **Press Shud. for more than 2 and less than 5 seconds:** Blue Lizard will not shut down, but it will restart the controller software – the WLAN access point remain alive, and after approximately 10 seconds, the software comes back to life. *This is recommended when setting the system up as described in Sects. 2.1 – 2.6.*

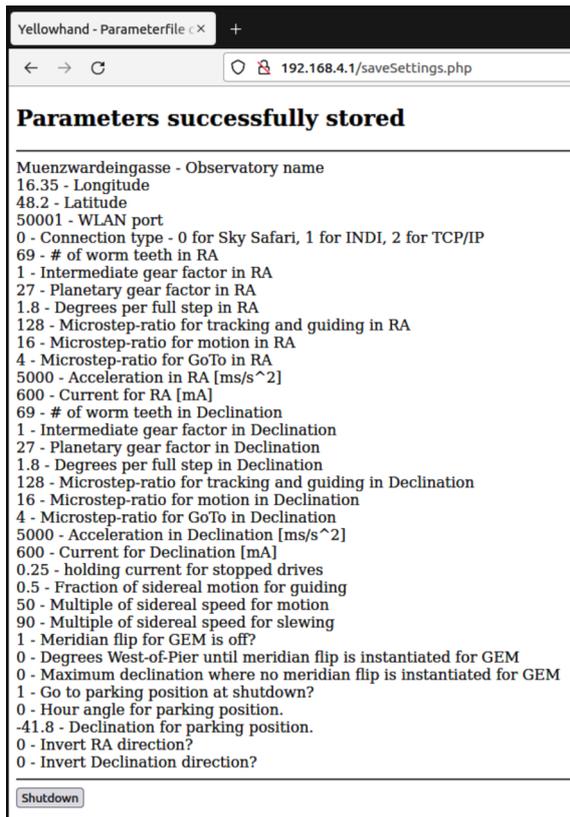


Figure 6: After submitting your settings via the *Submit Query* button on the parameter page in your browser, the stored parameters can be checked. It is necessary to restart the controller, or to shut it down. Shutdown is possible via the *Shutdown* button in the browser window, or by operating the *Shutd.* button (c in Fig. 1). With this button it is possible to restart the controller software without shutting BlueLizard down.

- **Press Shutd. for more than 5 seconds:** Blue Lizard shuts down completely; after approximately ten seconds, it is safe to disconnect the power, either by using the *Off/On* switch (b in Fig. 1), or by disconnecting the power. A restart is initiated by toggling the *Off/On* switch.

3 Planetarium programs

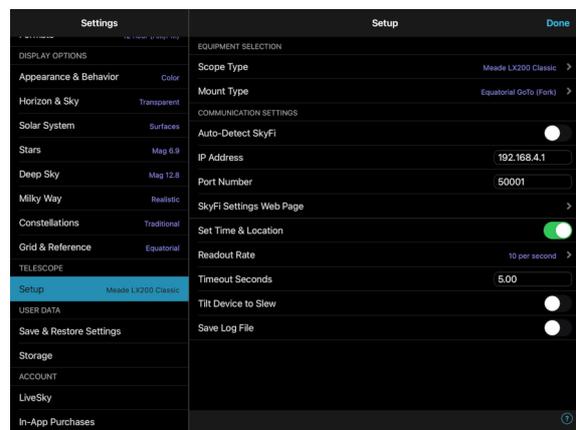


Figure 7: The *Setup* screen of *Sky Safari Plus* – here, the basic settings for connecting to Blue Lizard are shown.

Once all is set up, one can do first tests; as Blue Lizard only has very limited display functionality, *it is necessary to connect a planetarium program.* The following programs were tested:

3.1 Sky Safari

Take care that the connection method selected is *Sky Safari* as described in Sect. 2.1. The procedure is the same for iOS and Android.

- Connect to the access point of Blue Lizard as shown in Fig. 3.
- You need an advanced version of *Sky Safari* such as *Sky Safari Plus*, which is available for a few Euros in the App Stores.
- Start *Sky Safari* and go to the *Settings menu*; in the *Telescope* menu (Fig. 7), choose
 - Scope type → Meade LX200 Classic.

- Mount type → Equatorial GoTo (Fork). This is necessary in order to avoid that both Blue Lizard *and* the planetarium software trigger a meridian flip on a GEM.
 - IP Address → 192.168.4.1 (or whatever the IP address of Blue Lizard is).
 - Port Number → 50001 (or whatever port was set in the settings).
 - Turn on *Set Time & Location* by moving the switch to the right – this synchronizes the internal real-time clock of Blue Lizard and sets the location as received by the GPS-receiver of your tablet.
 - Readout Rate → 10 per second.
 - Confirm by pressing *Done* in the upper right corner.
- Now go to the *Scope* menu in the main screen of *Sky Safari* and press *Connect* (Fig. 8).
 - After connection – this may take a few seconds – the location of the scope is displayed as a crosshair (Fig. 9). Motion buttons appear on the left and right side, four different speeds can be selected in the *Rate* menu, and it is possible to synchronize the scope to a star with the *Align* button. One can select a celestial object and trigger a slew by selecting the *GoTo* command.



Figure 8: By selecting the *Scope* menu in Sky Safari Plus or higher versions, one can now connect to the controller.



Figure 9: The interface for controlling Blue Lizard after connection to *Sky Safari*.

3.2 INDI

INDI is a very powerful server concept for connecting all kinds of astronomical hardware in a networked environment. Amongst others, INDI can of course handle the *LX200* command set for telescope control. Two examples of planetarium programs connecting to an internal INDI server of Blue Lizard are presented in this section.

3.2.1 Stellarium

Select *INDI* in the setup as described in Sect. 2.1 and restart Blue Lizard. Now you can connect to Blue Lizard via an INDI server. Two popular programs using INDI are *Stellarium* and *KStars* – the latter is very well known for its integration with the *Astroberry* distribution.

- Connect your computer to the wireless access point of Blue Lizard.
- Start *Stellarium*, open the *Configuration Window* in the left popup menu (or by pressing F2), scroll to *Plugins* → *Telescope Control*, check *Load at startup* and click *configure*. See also Fig. 10.
- Select *INDI/INDIGO*, give your telescope a name, set an equinox and a short connection delay, and check whether you want to connect at startup (Fig. 11).

- Scroll down in the *Telescope properties* subdialogue and select the IP address of the host running the INDI server (that is actually Blue Lizard) to 192.168.4.1 (or whatever the IP Address of Blue Lizard is). Set the *Port* to 7624 – that is the default port used by INDI. If you push the *Refresh devices* button, you will see that a connection to an INDI server running the *LX200 Basic* protocol is established. Now you can close these dialogues. See also Fig. 12.
- Now you can close all dialogues; by pressing the *Telescope* button in the lower popup menu of Stellarium, you can open the INDI dialogue. The coordinates of a selected object can be transferred with the *Current object* button, and one can align or slew to this object. Manual motion with direction buttons at the four different speeds of LX200 is also possible (Fig. 13).

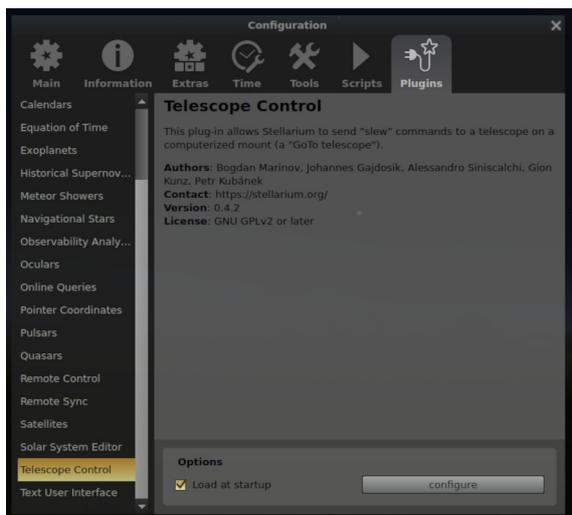


Figure 10: The *Plugins* menu of *Stellarium*, where the INDI interface is selected.

3.2.2 KStars and Astroberry

KStars is a very powerful program that fully integrates with INDI and it also features a powerful scheduler for astrophotography called *EKOS*. Here, we just show how *KStars* connects to the internal INDI server of Blue Lizard running a *LX200 Basic* driver. *KStars* has become quite popular as it is the

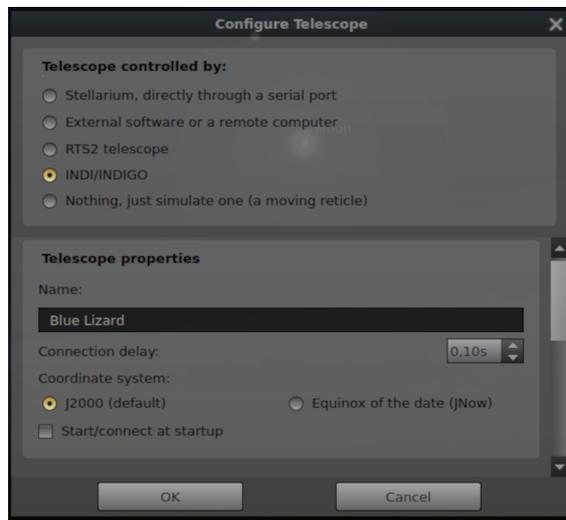


Figure 11: The first part of the *Configure Telescope* screen of *Stellarium*. **INDI/INDIGO** needs to be selected as the connection method.

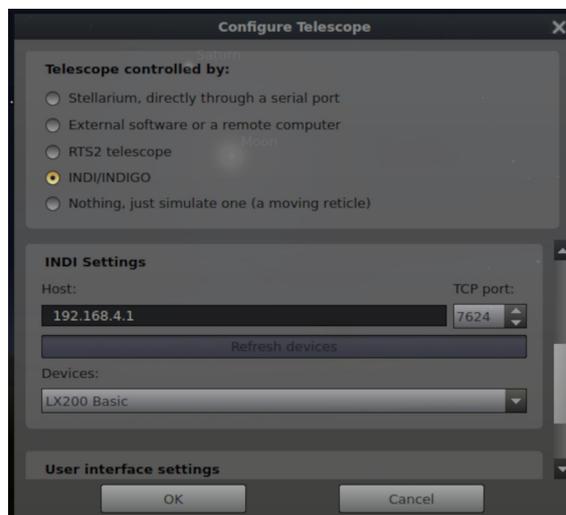


Figure 12: Set the proper IP address of Blue Lizard, set the port to **7624**, and connect to the INDI server.

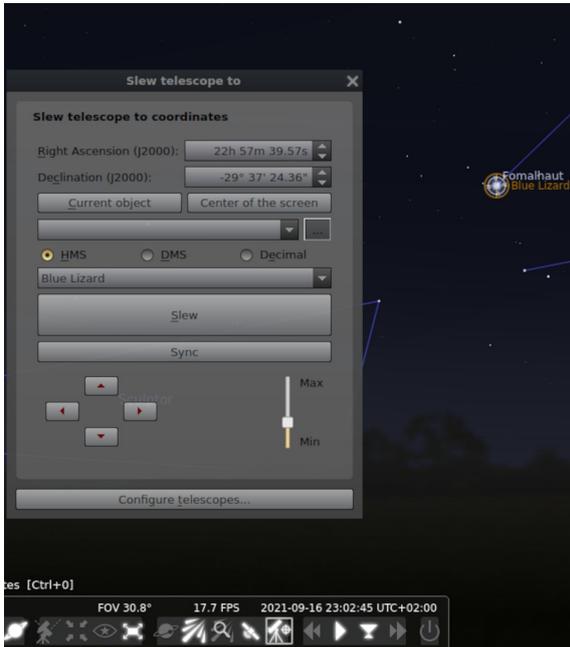


Figure 13: Telescope motion with INDI in *Stellarium*. The Telescope button in the bottom menu opens a dialogue for interaction with the controller.

central component for the *Astroberry* distribution for the Raspberry Pi.

- Start *KStars*, and select Tools → Devices → Device Manager ... – see also Fig. 14.
- Open the *Client* tab and *Add* the INDI server by entering a name, the IP Address of Blue Lizard and again the port of the INDI server on Blue Lizard – this is fixed to 7624 (Fig. 15). Press *Connect* to connect to the INDI server of Blue Lizard.
- By right-clicking in the main window of *KStars*, you can open the *LX200 Basic menu* for telescope operation (Fig. 16).

3.2.3 TCP/IP and ASCOM

In order to use the *LX200* command set directly via TCP/IP, you have to select *TCP/IP* in the setup as described in Sect. 2.1 and restart Blue Lizard. For *ASCOM* use, need to download the *Advanced*

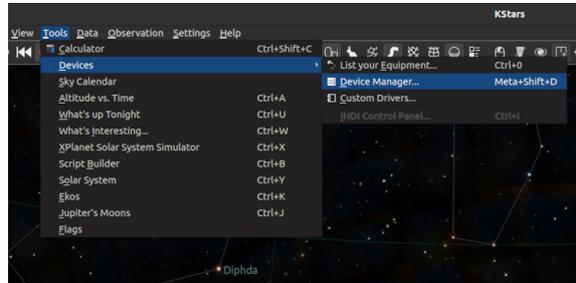


Figure 14: Connecting to an INDI Server in *KStars* is especially easy – just open the **Tools** → **Devices** → **Device Manager ...** dialogue ...

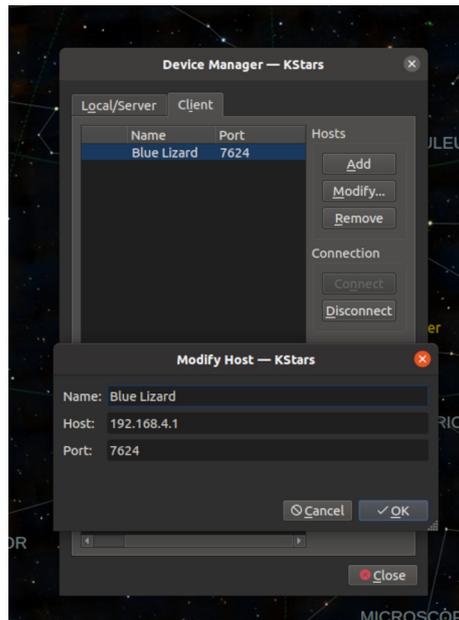


Figure 15: ...and **Add** the INDI server of Blue Lizard with the appropriate IP Address (192.168.4.1 by default and the port 7624. Click **Connect** to establish a connection and close all dialogues.

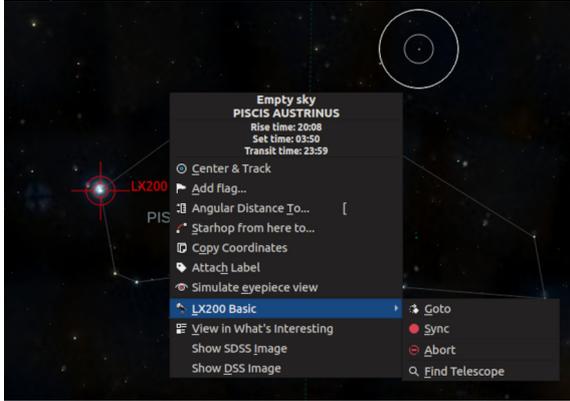


Figure 16: After connection, the **LX200 Basic** menu can be opened by a right-click with the mouse.

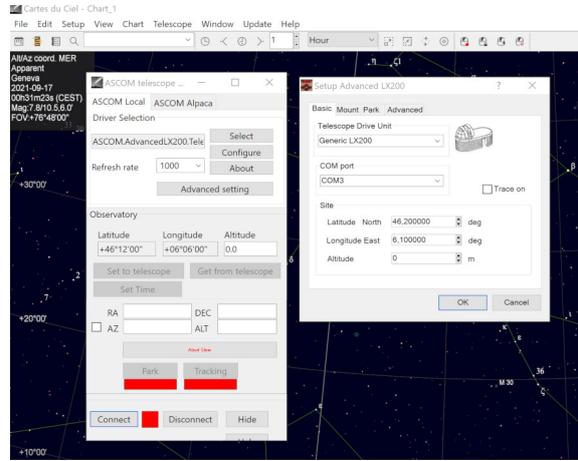


Figure 18: The interface of the *Advanced LX200 ASCOM driver*. The COM port selected is the USB-to-Serial interface of noted as *USB 2* on the controller.

*LX200 ASCOM driver*⁷ and connect the USB port of your computer to the *USB2* outlet of the controller. The interface needs to be set to **Serial**.

In this example, we connect *Cartes du Ciel*⁸ via *ASCOM* to *Blue Lizard*. The operating system used here is Windows 10.

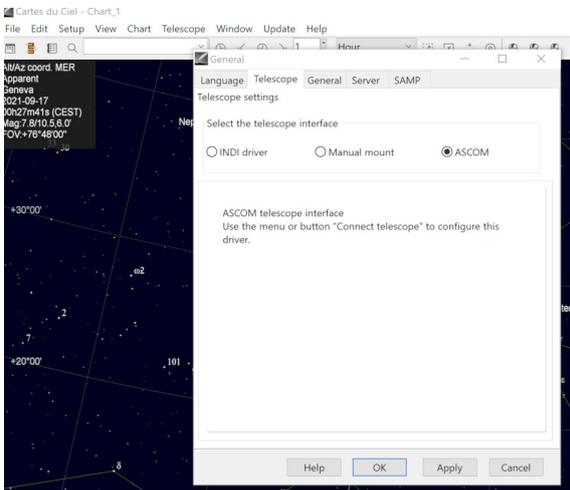


Figure 17: Selection of the *ASCOM* interface in *Cartes du Ciel*. Denote that *INDI* is available as well ...

- Go to *Telescope* → *Telescope Settings* and select *ASCOM* as the telescope interface (Fig. 17).
- Select the *Advanced LX200 ASCOM driver* that needs to be installed beforehand. The *COM-port* offered is most likely the USB-to-serial converter of *Blue Lizard* (Fig. 18). Denote that the meridian flip can also be triggered by the driver here (Fig. 19). If you choose this option, the meridian flip has to be disabled in the *Blue Lizard* controller. In this case, the controller does the meridian flip, therefore we set the *ASCOM* driver to a fork mount (Fig. 19).
- Once all is set up, a connection can be established (Fig. 20) and a right click on an object allows to align or slew the telescope. Denote

⁷<https://pixeltelescopes.wordpress.com/advanced-lx200/>

⁸<https://www.ap-i.net/skychart/en/start>

that synchronization of *Hiawatha* and the program can be complicated. The central button on *Hiawatha* allows to reset the interface.

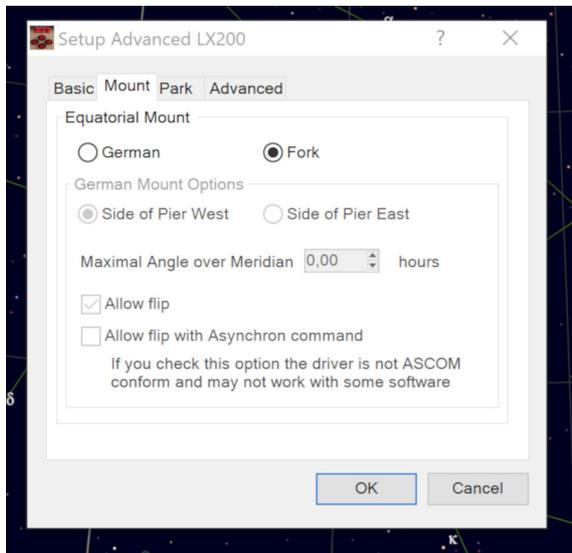


Figure 19: The *Advanced LX200 ASCOM driver* allows to trigger a meridian flip as well. Greatest care has to be taken that only one of the two devices – the driver *or* Blue Lizard – perform a meridian flip in a GEM.

It is also worth mentioning that *KStars* allows a direct LX200 connection via the serial interface to Blue Lizard.

4 Setting time and location

At this point, you are almost done – the mount parameters are entered, the planetarium program is connected – but you still need to set the time for the controller, otherwise it is not possible to translate celestial coordinates given in right ascension and declination to topical coordinates of hour angle and declination. Therefore, you have to set the real time clock of Blue Lizard. The RTC is a battery powered DS3231 chip, it is temperature compensated and the battery should keep the time for a number of years. Of course it is possible to replace the CR1220 battery once it is drained. But one has to set the time.

Your Blue Lizard should come with the time and date set properly. Upon startup, you can check this

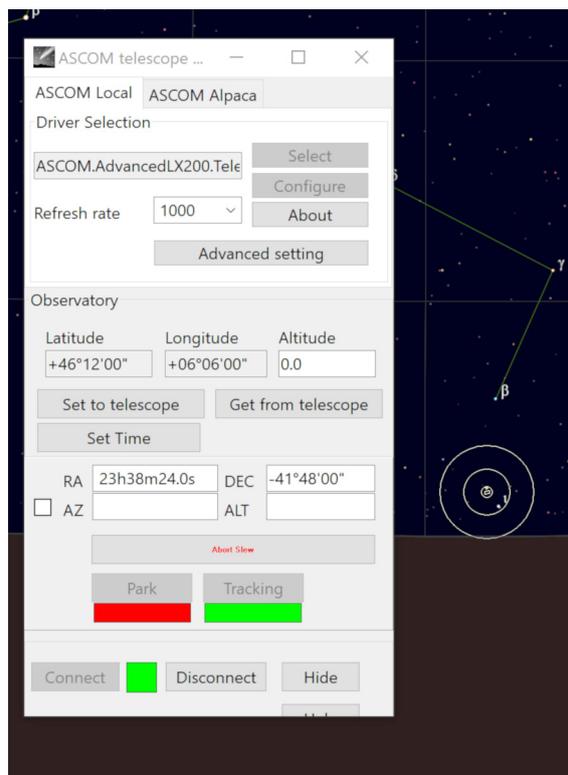


Figure 20: Once the *ASCOM driver* is set up, one can connect via *USB 2* to Blue Lizard. A right click on a celestial object opens the command interface to control the telescope. Denote that it is also possible to set the time via the *ASCOM* interface.

as the time and date of startup are displayed on the small screen attached to Blue Lizard (see also Fig. 2). If that time is not correct, the time has to be set. There is a multitude of methods to do this:

- **Set the time via LX200 and Sky Safari:**
As shown in Fig. 7, one can force *Sky Safari* to submit the topical time and location – *this is extremely useful for mobile use*. Setting the time also synchronizes the RTC.
- **Set the time with LX200 on a computer:**
Some interfaces like the *ASCOM* LX200 driver and *KStars* also allow for synchronization via LX200 (see also Fig. 20). This works in the same way as for *Sky Safari* – but take care that the time on your computer is set properly.

It is also possible to set the time manually, this is described in Sect. 8.

5 The handbox

A handbox is available for Blue Lizard. It connects to the ST4 port with a *twisted* RJ12 cable.

The handboxes have an hierarchical order – if any of the two handboxes is connected, LX200 handbox commands such as the direction buttons of Sky Safari are disabled. Therefore it is made sure that only one handbox at a time can issue commands.

6 Operation

Once all is set up, the time and date are set and all is connected, Blue Lizard simply responds to your commands via the planetarium program or the handbox. However, during startup there is another important phase when using a GEM – you have to tell the controller whether the mount is located **LEFT** or *right* of the pier. The controller starts beeping in that phase and the small display asks **Is scope LEFT?**. If the the scope is indeed located on the left side of the pier (this is also called *East-of-Pier* when looking at the south horizon, you do not have to do anything. *If the scope is on the right side of the pier, push the momentary East/West button on the front panel*. This is marked as button **c** in Fig. 2.

You can also change the tracking speed by pressing the momentary **Speed** button (marked as **b** in

Fig. 2). If you push this button, the tracking speed changes from sidereal speed to lunar and solar speed.

7 Guiding via ST4

Guiding via ST4 is realized when connecting a *straight* RJ12 cable to the ST4 port (marked as **d** in Fig. 1). This cable can be connected to the ST4 port of a camera or to any ST4 guider such as the Lacerta MGEN. *When a guiding command is received, Blue Lizard goes into a Guide mode*. This is displayed on the front display. In guide mode, Blue Lizard *ignores* most external commands – the handbox is disabled, and one cannot send any LX200 commands. After 30 seconds when no commands are reaching the system any more, Blue Lizard leaves the guide mode and resumes normal operation.

8 Connecting to Blue Lizard via RDP

If you want to see what is happening under the hood, you can also connect to the raspberry directly via RDP.

Above all, it is possible to set the real time clock here. Open an additional terminal window and connect Blue Lizard via an Ethernet cable to your router. After a few seconds, the time should be set. If you type `sudo hwclock -w` into the terminal, your clock should be set as well. Typing the command `sudo timedatectl set-time 'yyyy-mm-dd hh:mm:ss'` followed by `sudo hwclock -w`, the internal hardware clock can be set, for instance after a battery change.