

Twelve Seconds of Light

She photographs a galaxy she will never see with her own eyes — twelve seconds at a time, four hundred times a night.

6 min read

Before you read

- **arid** — extremely dry, with very little rainfall
- **aperture** — the opening that lets light into a camera or telescope
- **exposure** — the length of time a sensor is allowed to collect light
- **composite** — a single image assembled from many separate images
- **meticulous** — showing great attention to small details
- **ambient** — present in the surrounding environment
- **vocation** — work a person feels strongly called to do
- **threshold** — the point at which something becomes detectable or begins



A red screen, a tracking mount, and four hundred exposures still to go

¹ Valentina Rojas does her best work between one and five in the morning, in a place where the air is so dry that her hands crack and so clear that the Milky Way casts a shadow. She is seventeen. The nearest streetlight is forty minutes down the road, and she regards it as a personal opponent.

² The Atacama is the most arid non-polar desert on Earth, and that is precisely why the world's major observatories are built along its spine. Water vapour blurs and absorbs starlight; there is almost none here. What professional astronomers pay hundreds of millions for, Valentina gets by driving out of town

with a telescope that cost less than a second-hand motorcycle.

Why twelve seconds

³ Her target tonight is a galaxy roughly thirty million light years away, faint enough that a single photograph of it shows nothing at all — a grey rectangle with a little noise in it. The light arriving from it is below the threshold at which her sensor can distinguish signal from the random electrical fizz of the camera itself.

⁴ The answer is not one long exposure. Leave the shutter open for two hours and the Earth's rotation smears every star into an arc; even with a mount that tracks the sky, tiny errors accumulate and the ambient glow from the horizon slowly floods the frame. Instead she takes four hundred exposures of twelve seconds each and stacks them in software afterwards.

⁵ The reason this works is worth understanding, because it is not obvious. The noise in each frame is random: bright in one pixel this time, dark in the same pixel the next. The galaxy is not random — it is in the same place every time. Average hundreds of frames together and the random component cancels itself towards grey while the faint, consistent signal survives. The galaxy does not get brighter. The noise gets quieter.

The unglamorous part

⁶ Most of the night is not spent looking at anything. It is spent on calibration frames: photographs of the inside of a lens cap, to record what the sensor produces when no light reaches it at all, and photographs of an evenly lit surface, to record which parts of the optics transmit slightly less light than others. Dust on the sensor leaves a faint doughnut in every frame. It has to be measured before it can be removed.

⁷ She is meticulous about this in a way that surprises people who imagine astrophotography as a romantic pursuit. Her notebook records the temperature of the camera at every hour, because sensor noise rises with heat and the frames must be matched to calibration taken at the same temperature. There is a column for humidity. There is a column for how many frames she threw away because a satellite crossed them.

What the picture is

⁸ The composite that emerges after an evening of processing is not a photograph in the sense a holiday snapshot is. No human eye at the eyepiece would ever see those colours or that structure; the faintest detail in it was never visible to anyone at any moment. It is a measurement, rendered as an image — a record of how many photons arrived in each position over eighty accumulated minutes.

⁹ Valentina is relaxed about this. She points out that nobody accuses a thermometer of dishonesty for showing a number the skin cannot feel, and that the structure in her image is really there, in the sense

that it would be there whether or not she had pointed a camera at it. What has been removed is her own limitation, not the subject's reality.

¹⁰ She intends to study physics, and she is clear-eyed about the gap between what she does now and what research astronomy involves — the queueing for telescope time, the years on one narrow question, the papers that confirm something unexciting. She says the four hundred exposures taught her the part that actually transfers: the discipline of extracting something real from data that is mostly noise, and the patience to accept that this is what the work is.

Part A Choose the best answer

Circle the letter next to the right answer.

1. Why are major observatories built in the Atacama?

- A The altitude reduces the cost of construction
- B The air is extremely dry, so little water vapour blurs or absorbs starlight
- C There is no light pollution anywhere in Chile
- D The desert is close to the equator

2. Why does Valentina not simply take one very long exposure?

- A Her camera cannot stay open for longer than twelve seconds
- B Long exposures make the galaxy too bright to photograph
- C Tracking errors accumulate and ambient glow floods the frame
- D Stacking software requires frames of equal length

3. According to the passage, what does stacking actually achieve?

- A The galaxy becomes brighter in each frame
- B The random noise averages out while the consistent signal survives
- C The satellite trails are removed automatically
- D The sensor temperature is kept constant

4. Why does she photograph the inside of a lens cap?

- A To check the shutter is working
- B To record what the sensor produces when no light reaches it
- C To clean dust from the sensor
- D To measure the ambient glow from the horizon

5. What is Valentina's response to the idea that her image is not a real photograph?

- A She accepts it and calls the image an illustration
- B She argues the structure exists regardless of her camera, and only her own limitation has been removed
- C She says no photograph is ever truly accurate
- D She points out that professional astronomers do the same thing

Part B Write your answer

Answer in two or three sentences, using the passage as your evidence.

6. Explain in your own words why averaging many frames makes a faint object visible.

7. The writer says Valentina regards the nearest streetlight as 'a personal opponent'. What does this tell you about her, and about the conditions her work needs?

8. Why must her calibration frames be taken at the same temperature as her other frames?

9. The writer calls the final image 'a measurement, rendered as an image'. Explain the distinction being drawn.

Part C Think deeper

There is no single right answer here. Say what you think, and say why.

10. Valentina compares her image to a thermometer reading. How good is that comparison? Give one way it holds and one way it might break down.

- 11. She says the transferable lesson is 'extracting something real from data that is mostly noise'. Where else in life or study does that skill apply? Explain with an example.**

- 12. Most of her night is spent on work that produces no picture at all. Why do you think people underestimate this part of skilled work, and what follows from that misunderstanding?**

Answer key

For parents and teachers

Part A

1. **B** — The air is extremely dry, so little water vapour blurs or absorbs starlight | 2. **C** — Tracking errors accumulate and ambient glow floods the frame | 3. **B** — The random noise averages out while the consistent signal survives | 4. **B** — To record what the sensor produces when no light reaches it | 5. **B** — She argues the structure exists regardless of her camera, and only her own limitation has been removed

Part B

6. Noise appears in different pixels at random from frame to frame, so averaging drives it towards a flat grey; the galaxy's light falls in the same place every frame, so it survives the averaging. The signal does not increase — the noise decreases. Accept any answer distinguishing random from consistent, even without those words.

7. That she is single-minded and slightly obsessive about her conditions, and that her work needs darkness so complete that one distant light matters. Credit answers reading the phrase as humour revealing seriousness.

8. Because sensor noise rises with heat, so a calibration frame taken at a different temperature would record the wrong amount of noise and the correction would be inaccurate. Accept answers that link temperature to the noise being measured.

9. A photograph records what an eye could have seen at one moment; her image records how many photons arrived at each position over eighty minutes, a quantity no eye could perceive. It belongs with instruments rather than with snapshots. Accept answers that separate perception from measurement.

Part C

These answers vary. Mark the reasoning, not the answer.

10. A strong answer tests the analogy rather than agreeing with it. It holds because both instruments detect something real but imperceptible. It may break down because a thermometer returns a single number while an image involves processing choices — colour, contrast, what to discard — where a person's judgement enters. Reward anyone who finds that gap.

11. Mark the example and the reasoning, not the topic. Strong answers name a field where most input is irrelevant and the skill is separating signal from it: revision, sports statistics, news, medical diagnosis. Prompt with: what is the noise in your example, and how would you know you had removed it rather than the signal?

12. Look for a causal chain rather than a complaint. Common strong lines: visible output is all an outsider sees, so preparation is invisible and therefore assumed absent; the consequence is that people entering a field expect it to feel like the highlights and quit when it does not.

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