1
00:00:03,000 --> 00:00:06,000
This is the story of an epic adventure...

2
00:00:10,320 --> 00:00:15,320
A story of cosmic curiosity, courage and perseverance...

3
00:00:19,000 --> 00:00:24,000
The story of how Europe went South to explore the stars.

4
00:01:13,000 --> 00:01:17,000
Going South

5
00:01:18,000 --> 00:01:23,000
Welcome to ESO, the European Southern Observatory.

6
00:01:24,999 --> 00:01:28,400
Fifty years old, but more vital than ever.

7
00:01:34,520 --> 00:01:37,520
ESO is Europe’s portal to the stars.

8
00:01:38,280 --> 00:01:41,280
Here astronomers from fifteen countries

9
00:01:41,320 --> 00:01:44,240
join forces to unravel the secrets of the Universe.

10
00:01:44,960 --> 00:01:45,960
How?

11
00:01:45,999 --> 00:01:49,400
By building the largest telescopes on Earth.

12
00:01:49,440 --> 00:01:51,840
Designing sensitive cameras and instruments.

13
00:01:52,280 --> 00:01:54,280
Scrutinising the heavens.

14
00:01:57,000 --> 00:02:00,000
Their work has looked at objects near and far,

15
00:02:00,000 --> 00:02:03,000
from comets traversing the Solar System,

16
00:02:03,000 --> 00:02:06,560
to distant galaxies at the very edge of space and time,

17
00:02:06,600 --> 00:02:12,000
giving us fresh insights and an unprecedented view of the Universe.

18
00:02:42,560 --> 00:02:45,840
A Universe of deep mysteries and hidden secrets.

19
00:02:46,320 --> 00:02:48,080
And staggering beauty.

20
00:02:50,080 --> 00:02:52,080
From remote mountaintops in Chile,

21
00:02:52,120 --> 00:02:54,880
European astronomers are reaching for the stars.

22
00:02:55,999 --> 00:02:57,160
But why Chile?

23
00:02:57,160 --> 00:02:59,400
What made the astronomers go South?

24
00:03:02,560 --> 00:03:07,800
The European Southern Observatory has its Headquarters in Garching, Germany.

25
00:03:11,880 --> 00:03:16,000
But from Europe, only part of the sky can be seen.

26
00:03:16,000 --> 00:03:19,080
To fill in the gaps, you have to travel south.

27
00:03:27,880 --> 00:03:32,999
For many centuries, maps of the southern sky showed extensive blank areas –

28
00:03:33,000 --> 00:03:36,000
the Terra Incognita of the heavens.

29
00:03:37,200 --> 00:03:38,800
1595.

30
00:03:39,440 --> 00:03:43,320
For the first time, Dutch traders set sail to the East Indies.

31
00:03:49,880 --> 00:03:54,320
At night, navigators Pieter Keyser and Frederik de Houtman

32
00:03:54,320 --> 00:03:59,400

measured the positions of more than 130 stars in the southern sky.

33
00:04:05,600 --> 00:04:10,600
Soon, celestial globes and maps showed twelve new constellations,

34
00:04:10,640 --> 00:04:14,840
none of which had ever been seen before by any European.

35
00:04:16,280 --> 00:04:20,280
The British were the first to construct a permanent astronomical outpost

36
00:04:20,280 --> 00:04:21,920
in the southern hemisphere.

37
00:04:22,320 --> 00:04:27,320
The Royal Observatory at the Cape of Good Hope was founded in 1820.

38
00:04:28,640 --> 00:04:33,160
Not much later, John Herschel built his own private observatory,

39
00:04:33,160 --> 00:04:36,040
close to South Africa’s famous Table Mountain.

40
00:04:37,999 --> 00:04:38,999
What a view!

41
00:04:39,920 --> 00:04:44,920
Dark skies. Bright clusters and star clouds high overhead.

42
00:04:46,160 --> 00:04:49,999
Little wonder that Harvard, Yale and Leiden observatories

43
00:04:50,000 --> 00:04:53,720
followed suit with their own southern stations.

44
00:04:53,760 --> 00:04:57,000
But the exploration of the southern sky

45
00:04:57,000 --> 00:05:01,000
still took lots of courage, passion and perseverance.

46
00:05:06,400 --> 00:05:08,600
Until fifty years ago,

47
00:05:08,600 --> 00:05:12,240
almost all major telescopes were located north of the equator.

48

00:05:13,040 --> 00:05:15,360
So why is the southern sky so important?

49
00:05:17,680 --> 00:05:21,640
First of all, because it was largely uncharted territory.

50
00:05:22,120 --> 00:05:24,640
You just can’t see the whole sky from Europe.

51
00:05:25,320 --> 00:05:29,320
A prominent example is the centre of the Milky Way, our home galaxy.

52
00:05:29,880 --> 00:05:32,880
It can hardly be seen from the northern hemisphere,

53
00:05:32,920 --> 00:05:34,920
but from the south, it passes high overhead.

54
00:05:36,960 --> 00:05:38,960
And then there are the Magellanic Clouds –

55
00:05:38,999 --> 00:05:42,280
two small companion galaxies to the Milky Way.

56
00:05:42,440 --> 00:05:47,360
Invisible from the North, but very conspicuous if you’re south of the equator.

57
00:05:48,440 --> 00:05:49,440
And then finally,

58
00:05:49,520 --> 00:05:53,840
European astronomers were hindered by light pollution and poor weather.

59
00:05:53,880 --> 00:05:57,120
Going south would solve most of their problems.

60
00:06:00,080 --> 00:06:04,720
A scenic boat trip in the Netherlands, June 1953.

61
00:06:05,000 --> 00:06:07,600
It was here, on the IJsselmeer,

62
00:06:07,600 --> 00:06:10,600
that the German/American astronomer Walter Baade

63
00:06:10,600 --> 00:06:13,000
and the Dutch astronomer Jan Oort

64
00:06:13,000 --> 00:06:16,000
told colleagues about their plan for a European observatory

65
00:06:16,000 --> 00:06:18,000
in the southern hemisphere.

66
00:06:22,160 --> 00:06:26,720
Individually, no one European country could compete with the United States.

67
00:06:27,240 --> 00:06:29,240
But together, they might.

68
00:06:29,560 --> 00:06:34,560
Seven months later, twelve astronomers from six countries gathered here,

69
00:06:34,560 --> 00:06:37,080
in the stately Senate Room of Leiden University.

70
00:06:37,960 --> 00:06:39,400
They signed a statement,

71
00:06:39,400 --> 00:06:45,000
expressing the desire to establish a European observatory in South Africa.

72
00:06:45,040 --> 00:06:48,000
This paved the way for the birth of ESO.

73
00:06:48,760 --> 00:06:50,880
But hang on!… South Africa?

74
00:06:52,520 --> 00:06:54,440
Well, it made sense, of course.

75
00:06:54,600 --> 00:07:00,000
South Africa already had the Cape Observatory, and, after 1909,

76
00:07:00,000 --> 00:07:03,000
the Transvaal Observatory in Johannesburg.

77
00:07:03,000 --> 00:07:07,600
Leiden Observatory had its own southern station in Hartebeespoort.

78
00:07:09,960 --> 00:07:11,960
In 1955,

79
00:07:11,999 --> 00:07:17,520
astronomers set up test equipment to find the best possible spot for a big telescope.

80
00:07:17,600 --> 00:07:24,000
Zeekoegat in the Great Karoo. Or Tafelkopje, in Bloemfontein.

81
00:07:25,000 --> 00:07:27,640
But the weather was not all that favourable.

82
00:07:29,000 --> 00:07:34,720
Around 1960, the focus shifted to the rugged landscape of northern Chile.

83
00:07:35,640 --> 00:07:38,999
American astronomers were also planning

84
00:07:39,000 --> 00:07:41,600
their own southern hemisphere observatory here.

85
00:07:41,600 --> 00:07:48,000
Harsh horseback expeditions revealed much better conditions than in South Africa.

86
00:07:48,040 --> 00:07:52,400
In 1963, the die was cast. Chile it would be.

87
00:07:53,000 --> 00:07:56,000
Six months later, Cerro La Silla was picked

88
00:07:56,000 --> 00:07:59,520
as the future site of the European Southern Observatory.

89
00:07:59,800 --> 00:08:03,000
ESO was no longer a distant dream.

90
00:08:03,240 --> 00:08:10,280
In the end, five European countries signed the ESO Convention, on 5 October 1962 –

91
00:08:10,840 --> 00:08:15,680
the official birthday of the European Southern Observatory.

92
00:08:15,720 --> 00:08:19,600
Belgium, Germany, France, the Netherlands and Sweden

93
00:08:19,600 --> 00:08:24,000
were firmly committed to jointly reach for the southern stars.

94
00:08:25,680 --> 00:08:29,680
La Silla and its surroundings were bought from the Chilean government.

95
00:08:30,440 --> 00:08:32,720

A road was built in the middle of nowhere.

96
00:08:33,880 --> 00:08:38,999
ESO’s first telescope took shape, at a steel company in Rotterdam.

97
00:08:40,880 --> 00:08:43,600
And in December 1966,

98
00:08:43,640 --> 00:08:49,000
the European Southern Observatory opened its first eye on the sky.

99
00:08:49,000 --> 00:08:54,320
Europe had embarked on a grand voyage of cosmic discovery.

100
00:09:00,000 --> 00:09:05,000
Looking up

101
00:09:07,000 --> 00:09:14,640
167,000 years ago, a star exploded in a small galaxy orbiting the Milky Way.

102
00:09:17,720 --> 00:09:20,160
At the time of the distant explosion,

103
00:09:20,200 --> 00:09:24,440
Homo sapiens just started to roam the African savannah.

104
00:09:26,720 --> 00:09:29,640
But no one could have noticed the cosmic fireworks,

105
00:09:29,760 --> 00:09:34,920
as the blast of light had only just embarked on its long journey towards Earth.

106
00:09:36,240 --> 00:09:41,280
By the time light from the supernova had completed 98% of its journey,

107
00:09:41,360 --> 00:09:46,200
Greek philosophers had just started to think about the nature of the cosmos.

108
00:09:48,520 --> 00:09:50,840
Just before the light reached Earth,

109
00:09:50,920 --> 00:09:56,400
Galileo Galilei trained his first primitive telescopes on the heavens.

110
00:09:59,800 --> 00:10:03,000
And on 24 February 1987,

111

00:10:03,200 --> 00:10:07,280
when photons from the explosion finally rained down on our planet,

112
00:10:07,360 --> 00:10:12,200
astronomers were ready to observe the supernova in great detail.

113
00:10:13,760 --> 00:10:15,760
Supernova 1987A

114
00:10:15,800 --> 00:10:17,920
flared up in the southern sky –

115
00:10:17,999 --> 00:10:20,999
unobservable from Europe or the United States.

116
00:10:21,000 --> 00:10:25,560
But by this time, ESO had built its first big telescopes in Chile,

117
00:10:25,560 --> 00:10:30,000
providing astronomers with a front-row seat to this cosmic spectacle.

118
00:10:32,560 --> 00:10:35,440
The telescope is of course the central tool

119
00:10:35,480 --> 00:10:39,600
that allows us to unravel the secrets of the Universe.

120
00:10:40,400 --> 00:10:44,800
Telescopes collect far more light than the unaided human eye,

121
00:10:44,840 --> 00:10:49,480
so they reveal fainter stars and let us peer deeper into space.

122
00:10:51,480 --> 00:10:55,920
Like magnifying glasses, they also show finer detail.

123
00:10:57,680 --> 00:11:01,720
And, when equipped with sensitive cameras and spectrographs,

124
00:11:01,760 --> 00:11:07,000
they provide us with a wealth of information about planets, stars and galaxies.

125
00:11:14,360 --> 00:11:18,120
ESO’s first telescopes on La Silla were a mixed bunch.

126
00:11:18,160 --> 00:11:21,160
They ranged from small national instruments

127
00:11:21,200 --> 00:11:24,040
to large astrographs and wide-field cameras.

128
00:11:34,200 --> 00:11:38,360
The 2.2-metre telescope – now almost 30 years old –

129
00:11:38,400 --> 00:11:41,880
is still producing some of the most dramatic views of the cosmos.

130
00:12:22,720 --> 00:12:25,160
At the highest point of Cerro La Silla

131
00:12:25,160 --> 00:12:30,800
lies the biggest achievement of ESO's early years - the 3.6-metre telescope.

132
00:12:31,160 --> 00:12:35,480
Aged 35, it now leads a second life as a planet hunter.

133
00:12:37,000 --> 00:12:42,640
Also, Swedish astronomers built a shiny dish fifteen metres across

134
00:12:42,680 --> 00:12:46,120
to study microwaves from cool cosmic clouds.

135
00:12:47,280 --> 00:12:52,600
Together, these telescopes have helped to unveil the Universe in which we live.

136
00:13:06,840 --> 00:13:10,840
Earth is just one of eight planets in the Solar System.

137
00:13:16,160 --> 00:13:19,200
From tiny Mercury to giant Jupiter,

138
00:13:19,240 --> 00:13:24,960
these rocky spheres and gaseous balls are the leftovers from the formation of the Sun.

139
00:13:30,360 --> 00:13:35,360
The Sun, in turn, is a middle-of-the-road star in the Milky Way galaxy.

140
00:13:36,800 --> 00:13:42,080
One pinprick of light amidst hundreds of billions of similar stars –

141
00:13:42,160 --> 00:13:46,640
as well as bloated red giants, imploded white dwarfs,

142
00:13:46,800 --> 00:13:49,720
and rapidly spinning neutron stars.

143
00:13:50,920 --> 00:13:55,840
The spiral arms of the Milky Way are sprinkled with glowing nebulae,

144
00:13:56,000 --> 00:13:59,040
spawning bright clusters of newborn stars,

145
00:13:59,240 --> 00:14:03,640
while old globular clusters slowly swarm about the galaxy.

146
00:14:08,560 --> 00:14:13,400
And the Milky Way is just one of countless galaxies in a vast Universe,

147
00:14:13,400 --> 00:14:18,920
which has been expanding ever since the Big Bang, almost fourteen billion years ago.

148
00:14:26,440 --> 00:14:31,560
Over the past fifty years, ESO has helped to uncover our place in the Universe.

149
00:14:31,760 --> 00:14:36,000
And by looking up, we have also discovered our own origins.

150
00:14:36,240 --> 00:14:41,999
We are part of the big cosmic story. Without stars, we wouldn’t be here.

151
00:14:45,320 --> 00:14:50,320
The Universe started out with hydrogen and helium, the two lightest elements.

152
00:14:50,400 --> 00:14:55,720
But stars are nuclear ovens, turning light elements into heavier ones.

153
00:14:58,040 --> 00:15:01,560
And supernovae like 1987A

154
00:15:01,600 --> 00:15:05,680
seed the Universe with the products of this stellar alchemy.

155
00:15:08,440 --> 00:15:13,240
When the Solar System formed, some 4.6 billion years ago,

156
00:15:13,440 --> 00:15:16,960
it contained trace amounts of these heavier elements.

157
00:15:17,080 --> 00:15:21,400
Metals and silicates, but also carbon and oxygen.

158
00:15:22,600 --> 00:15:27,600

The carbon in our muscles, the iron in our blood, and the calcium in our bones,

159
00:15:27,600 --> 00:15:31,240
were all forged in an earlier generation of stars.

160
00:15:31,280 --> 00:15:34,000
You and I were literally made in heaven.

161
00:15:35,440 --> 00:15:38,800
But answers always lead to new questions.

162
00:15:39,080 --> 00:15:42,640
The more we learn, the deeper the mysteries become.

163
00:15:45,040 --> 00:15:48,560
What is the origin and ultimate fate of galaxies?

164
00:15:52,560 --> 00:15:57,560
Are there other solar systems out there, and could there be life on alien worlds?

165
00:16:05,080 --> 00:16:10,480
And what lurks in the dark heart of our Milky Way galaxy?

166
00:16:21,240 --> 00:16:25,000
Astronomers were clearly in need of more powerful telescopes.

167
00:16:25,000 --> 00:16:28,720
And ESO provided them with revolutionary new tools.

168
00:16:39,880 --> 00:16:44,440
Seeing Sharp

169
00:16:45,800 --> 00:16:49,360
Bigger is better - at least when it comes to telescope mirrors.

170
00:16:49,360 --> 00:16:54,440
But larger mirrors have to be thick, so that they don't deform under their own weight.

171
00:16:55,120 --> 00:16:59,400
And really large mirrors deform anyway, no matter how thick and heavy they are.

172
00:17:00,480 --> 00:17:07,160
The solution? Thin, lightweight mirrors - and a magic trick called active optics.

173
00:17:08,120 --> 00:17:11,360
ESO pioneered this technology in the late 1980s,

174

00:17:11,440 --> 00:17:13,840
with the New Technology Telescope.

175
00:17:15,240 --> 00:17:17,480
And this is the state of the art.

176
00:17:17,480 --> 00:17:23,560
The mirrors of the Very Large Telescope – the VLT – are 8.2 metres across...

177
00:17:23,560 --> 00:17:26,280
...but only 20 centimetres thick.

178
00:17:27,120 --> 00:17:28,120
And here's the magic:

179
00:17:28,760 --> 00:17:31,120
a computer-controlled support system ensures

180
00:17:31,120 --> 00:17:36,880
that the mirror keeps its desired shape at all times to nanometre precision.

181
00:17:53,200 --> 00:17:56,960
The VLT is ESO's flagship facility.

182
00:17:57,120 --> 00:18:03,600
Four identical telescopes, joining forces on top of Cerro Paranal, in the north of Chile.

183
00:18:03,640 --> 00:18:05,840
Built in the late 1990s,

184
00:18:05,840 --> 00:18:10,520
they provided astronomers with the best available technologies.

185
00:18:15,240 --> 00:18:20,720
In the middle of the Atacama Desert, ESO created an astronomer's paradise.

186
00:18:36,040 --> 00:18:38,360
Scientists stay in La Residencia,

187
00:18:38,360 --> 00:18:41,760
a guest house partly buried under the dirt and rubble

188
00:18:41,800 --> 00:18:44,160
of one of the driest places on the planet.

189
00:18:44,640 --> 00:18:50,720
But inside are lush palm trees, a swimming pool, and... delicious Chilean sweets.

190
00:18:53,640 --> 00:18:54,520
Of course,

191
00:18:54,560 --> 00:18:58,800
the unique selling point of the Very Large Telescope is not its swimming pool,

192
00:18:59,000 --> 00:19:02,560
but its unequalled view of the Universe.

193
00:19:07,400 --> 00:19:11,480
Without thin mirrors and active optics, the VLT would not be possible.

194
00:19:12,000 --> 00:19:13,080
But there’s more.

195
00:19:13,080 --> 00:19:18,320
Stars appear blurry, even when observed with the best and largest telescopes.

196
00:19:18,320 --> 00:19:22,360
The reason? The Earth’s atmosphere distorts the images.

197
00:19:26,920 --> 00:19:31,200
Enter the second magic trick: adaptive optics.

198
00:19:32,880 --> 00:19:39,200
On Paranal, laser beams shoot out into the night sky to create artificial stars.

199
00:19:39,200 --> 00:19:43,720
Sensors use these stars to measure the atmospheric distortions.

200
00:19:43,840 --> 00:19:46,080
And hundreds of times per second,

201
00:19:46,160 --> 00:19:50,200
the image is corrected by computer-controlled deformable mirrors.

202
00:19:52,240 --> 00:19:57,480
And the end effect? As if the turbulent atmosphere were completely removed.

203
00:19:57,840 --> 00:19:59,200
Just look at the difference!

204
00:20:06,240 --> 00:20:09,680
The Milky Way is a giant spiral galaxy.

205
00:20:09,680 --> 00:20:14,440
And at its core – 27 000 light-years away –

206
00:20:14,440 --> 00:20:19,400
lies a mystery that ESO’s Very Large Telescope helped to unravel.

207
00:20:21,640 --> 00:20:25,560
Massive dust clouds block our view of the Milky Way’s core.

208
00:20:25,640 --> 00:20:29,520
But sensitive infrared cameras can peer through the dust

209
00:20:29,600 --> 00:20:31,880
and uncover what lies behind.

210
00:20:37,640 --> 00:20:43,080
Assisted by adaptive optics they reveal dozens of red giant stars.

211
00:20:43,640 --> 00:20:47,520
And over the years, these stars are seen to move!

212
00:20:47,640 --> 00:20:52,320
They orbit an invisible object at the very centre of the Milky Way.

213
00:20:53,760 --> 00:20:59,440
Judging from the stellar motions, the invisible object must be extremely massive.

214
00:21:00,200 --> 00:21:06,800
A monstrous black hole, weighing in at 4.3 million times the mass of our Sun.

215
00:21:07,520 --> 00:21:11,600
Astronomers have even observed energetic flares from gas clouds

216
00:21:11,600 --> 00:21:13,640
falling into the black hole.

217
00:21:13,800 --> 00:21:18,160
All exposed by the sheer power of adaptive optics.

218
00:21:20,120 --> 00:21:25,160
So thin mirrors and active optics make it possible to build giant telescopes.

219
00:21:25,200 --> 00:21:28,680
And the adaptive optics take care of the atmospheric turbulence,

220
00:21:28,680 --> 00:21:31,200
providing us with extremely sharp images.

221
00:21:32,000 --> 00:21:34,640

But we're not done yet with our magic tricks.

222
00:21:34,680 --> 00:21:38,240
There's a third one. And it's called interferometry.

223
00:21:40,680 --> 00:21:44,360
The VLT consists of four telescopes.

224
00:21:44,360 --> 00:21:49,960
Together, they can act as a virtual telescope measuring 130 metres across.

225
00:21:52,520 --> 00:21:57,560
Light collected by the individual telescopes is channelled through evacuated tunnels

226
00:21:57,560 --> 00:22:00,800
and brought together in an underground laboratory.

227
00:22:03,000 --> 00:22:09,000
Here, the light waves are combined using laser metrology and intricate delay lines.

228
00:22:13,960 --> 00:22:19,240
The net result is the light-gathering power of four 8.2-metre mirrors,

229
00:22:19,280 --> 00:22:25,440
and the eagle-eyed vision of an imaginary telescope as large as fifty tennis courts.

230
00:22:28,040 --> 00:22:32,080
Four auxiliary telescopes give the network more flexibility.

231
00:22:32,120 --> 00:22:35,840
They may appear tiny next to the four giants.

232
00:22:35,960 --> 00:22:40,400
Yet, they sport mirrors 1.8 metres across.

233
00:22:40,800 --> 00:22:45,360
That’s bigger than the largest telescope in the world just a hundred years ago!

234
00:22:47,040 --> 00:22:50,360
Optical interferometry is something of a miracle.

235
00:22:50,640 --> 00:22:54,400
Starlight magic, wielded in the desert.

236
00:22:54,960 --> 00:22:58,160
And the results are impressive.

237

00:22:59,920 --> 00:23:05,120
The Very Large Telescope Interferometer reveals fifty times more detail

238
00:23:05,160 --> 00:23:07,160
than the Hubble Telescope.

239
00:23:09,640 --> 00:23:14,440
For instance, it gave us a close-up of a vampire double star.

240
00:23:15,960 --> 00:23:19,320
One star is stealing material from its companion.

241
00:23:23,480 --> 00:23:28,240
Irregular puffs of stardust have been detected around Betelgeuse –

242
00:23:28,240 --> 00:23:32,200
a stellar giant about to go supernova.

243
00:23:34,560 --> 00:23:40,360
And in dusty discs surrounding newborn stars, astronomers have found ...

244
00:23:40,480 --> 00:23:44,280
... the raw material of future Earth-like worlds.

245
00:23:44,760 --> 00:23:50,400
The Very Large Telescope is mankind’s sharpest eye on the sky.

246
00:23:51,200 --> 00:23:54,880
But astronomers have other means to expand their horizons

247
00:23:54,880 --> 00:23:57,320
and broaden their views.

248
00:23:57,320 --> 00:23:59,999
At the European Southern Observatory,

249
00:24:00,000 --> 00:24:05,400
they have learned to see the Universe in a completely different kind of light.

250
00:24:11,920 --> 00:24:18,720
Changing Views

251
00:24:24,400 --> 00:24:25,720
Great music, isn’t it?

252
00:24:26,880 --> 00:24:29,640
But suppose you had a hearing impairment.

253
00:24:29,640 --> 00:24:32,720
What if you couldn't hear the low frequencies?

254
00:24:34,080 --> 00:24:35,880
Or the high frequencies?

255
00:24:37,640 --> 00:24:40,320
Astronomers used to be in a similar situation.

256
00:24:41,080 --> 00:24:46,400
The human eye is only sensitive to a small part of all the radiation in the Universe.

257
00:24:46,400 --> 00:24:50,400
We can’t see light with wavelengths shorter than violet waves,

258
00:24:50,400 --> 00:24:52,480
or longer than red waves.

259
00:24:53,160 --> 00:24:56,320
We just don’t perceive the whole cosmic symphony.

260
00:24:58,160 --> 00:25:03,880
Infrared, or heat radiation, was first discovered by William Herschel, in 1800.

261
00:25:07,480 --> 00:25:10,560
In a dark room, you can’t see me.

262
00:25:11,720 --> 00:25:15,960
But put on infrared goggles, and you can “see” my body warmth.

263
00:25:18,760 --> 00:25:25,160
Likewise, infrared telescopes reveal cosmic objects too cool to give off visible light,

264
00:25:25,160 --> 00:25:29,800
like dark clouds of gas and dust where stars and planets are born.

265
00:25:38,880 --> 00:25:39,880
For decades,

266
00:25:39,920 --> 00:25:42,640
ESO astronomers have been keen to explore the Universe

267
00:25:42,640 --> 00:25:44,560
at infrared wavelengths.

268
00:25:45,120 --> 00:25:48,240
But the first detectors were small and hence inefficient.

269
00:25:48,600 --> 00:25:52,000
They gave us a blurry view of the infrared sky.

270
00:25:54,160 --> 00:25:58,120
Today’s infrared cameras are huge and powerful.

271
00:25:58,720 --> 00:26:02,800
They’re cooled to very low temperatures to increase their sensitivity.

272
00:26:04,400 --> 00:26:09,240
And ESO’s Very Large Telescope is designed to make good use of them.

273
00:26:14,080 --> 00:26:20,960
In fact, some technological tricks, like interferometry, only work in the infrared.

274
00:26:23,120 --> 00:26:27,560
We’ve broadened our view, to reveal the Universe in a new light.

275
00:26:31,040 --> 00:26:37,440
This dark blob is a cloud of cosmic dust. It blots out the stars in the background.

276
00:26:37,480 --> 00:26:41,960
But in the infrared, we can look straight through the dust.

277
00:26:43,840 --> 00:26:47,600
And here’s the Orion Nebula, a stellar nursery.

278
00:26:47,640 --> 00:26:52,480
Most of the newborn baby stars are hidden by dust clouds.

279
00:26:52,480 --> 00:26:58,160
Again, infrared comes to the rescue, revealing stars in the making!

280
00:27:09,080 --> 00:27:13,160
At the end of their lives, stars blow out bubbles of gas.

281
00:27:13,160 --> 00:27:16,880
Cosmic showpieces at optical wavelengths

282
00:27:16,880 --> 00:27:21,000
– but the infrared picture shows much more detail.

283
00:27:23,280 --> 00:27:25,600
Don’t forget the stars and gas clouds

284
00:27:25,600 --> 00:27:30,680

captured by the monstrous black hole in the core of our Milky Way galaxy.

285
00:27:30,720 --> 00:27:34,400
Without infrared cameras we would never see them.

286
00:27:36,360 --> 00:27:37,720
In other galaxies,

287
00:27:37,720 --> 00:27:42,880
infrared studies have revealed the true distribution of stars like our own Sun.

288
00:27:45,920 --> 00:27:49,920
The farthest galaxies can only be studied in the infrared.

289
00:27:49,920 --> 00:27:52,640
Their light has been shifted to these long wavelengths

290
00:27:52,640 --> 00:27:54,880
by the expansion of the Universe.

291
00:27:57,200 --> 00:28:01,640
Close to Paranal is a small mountain peak with an isolated building on top.

292
00:28:02,160 --> 00:28:05,880
Inside this building is the 4.1-metre VISTA telescope.

293
00:28:06,280 --> 00:28:09,960
It was built in the United Kingdom, ESO’s tenth Member State.

294
00:28:17,120 --> 00:28:20,640
For now, VISTA only does infrared.

295
00:28:20,640 --> 00:28:25,400
It uses a giant camera, weighing as much as a pickup truck.

296
00:28:25,400 --> 00:28:31,960
And yes, VISTA offers unprecedented vistas of the infrared Universe.

297
00:28:33,320 --> 00:28:37,080
ESO has been doing optical astronomy since its birth, fifty years ago.

298
00:28:40,080 --> 00:28:43,240
And infrared astronomy for about thirty years.

299
00:28:48,480 --> 00:28:51,480
But there are more registers to the cosmic symphony.

300

00:28:53,160 --> 00:28:57,640
Five thousand metres above sea level, high in the Chilean Andes,

301
00:28:57,640 --> 00:28:59,800
is the Chajnantor plateau.

302
00:29:01,040 --> 00:29:04,160
Astronomy doesn't go higher than this.

303
00:29:07,320 --> 00:29:10,160
Chajnantor is home to ALMA

304
00:29:11,200 --> 00:29:14,640
– the Atacama Large Millimeter/submillimeter Array.

305
00:29:15,720 --> 00:29:17,560
ALMA is still under construction.

306
00:29:17,600 --> 00:29:21,400
At a site that is so hostile, it's even hard to breathe!

307
00:29:24,360 --> 00:29:27,560
With just ten of the 66 antennas in place,

308
00:29:27,560 --> 00:29:32,080
ALMA made its first observations in the autumn of 2011.

309
00:29:36,200 --> 00:29:42,600
Millimetre waves from space. To observe them, you need to be high and dry.

310
00:29:42,640 --> 00:29:47,240
Chajnantor is one of the best places in the world for this.

311
00:29:51,840 --> 00:29:57,440
Clouds of cold gas and dark dust become visible in a pair of colliding galaxies.

312
00:29:58,040 --> 00:30:02,880
This is not where stars are born, but where they are conceived.

313
00:30:05,880 --> 00:30:09,560
And these spiral waves in the outflow of a dying star

314
00:30:09,560 --> 00:30:12,640
– could they be due to an orbiting planet?

315
00:30:17,040 --> 00:30:18,880
By changing the way we look,

316
00:30:18,880 --> 00:30:23,080
we’re closing in on the origins of planets, stars and galaxies.

317
00:30:23,560 --> 00:30:26,880
On the full symphony of the cosmos.

318
00:30:37,999 --> 00:30:42,640
Reaching out

319
00:30:44,640 --> 00:30:47,720
Stephane Guisard loves the stars.

320
00:30:48,800 --> 00:30:51,240
No wonder he loves northern Chile, too.

321
00:30:52,280 --> 00:30:56,560
Here, the view of the Universe is amongst the best in the world.

322
00:30:58,080 --> 00:31:01,280
And no wonder he loves the European Southern Observatory

323
00:31:01,320 --> 00:31:03,640
– Europe’s eye on the sky.

324
00:31:04,760 --> 00:31:08,320
Stephane is a prize-winning French photographer and author.

325
00:31:10,240 --> 00:31:14,080
He is also one of ESO’s Photo Ambassadors.

326
00:31:18,760 --> 00:31:23,880
In breathtaking pictures, he captures the solitude of the Atacama desert,

327
00:31:23,880 --> 00:31:26,920
the high-tech perfection of giant telescopes,

328
00:31:26,960 --> 00:31:30,640
and the magnificence of the night sky.

329
00:31:38,440 --> 00:31:42,280
Like his fellow photo ambassadors from all over the world,

330
00:31:42,320 --> 00:31:45,640
Stephane helps in spreading ESO’s message.

331
00:31:47,160 --> 00:31:51,240
A message of curiosity, wonder and inspiration,

332
00:31:51,240 --> 00:31:54,720
proclaimed through cooperation and outreach.

333
00:31:57,800 --> 00:32:01,360
Cooperation has always been the basis of ESO’s success.

334
00:32:01,560 --> 00:32:02,560
Fifty years ago,

335
00:32:02,720 --> 00:32:04,240
the European Southern Observatory

336
00:32:04,280 --> 00:32:07,160
started out with five founding member states:

337
00:32:07,160 --> 00:32:11,240
Belgium, France, Germany, the Netherlands and Sweden.

338
00:32:11,640 --> 00:32:14,080
Soon, other European countries followed.

339
00:32:14,400 --> 00:32:20,560
Denmark in 1967. Italy and Switzerland in 1982. Portugal in 2001.

340
00:32:20,560 --> 00:32:22,720
The United Kingdom in 2002.

341
00:32:23,600 --> 00:32:28,080
Over the past decade, Finland, Spain, the Czech Republic and Austria

342
00:32:28,080 --> 00:32:31,480
also joined Europe’s largest astronomy organisation.

343
00:32:32,480 --> 00:32:36,200
Most recently, Brazil became ESO’s 15th Member State,

344
00:32:36,240 --> 00:32:39,080
and the first non-European country to join.

345
00:32:39,480 --> 00:32:41,320
Who knows what the future will bring?

346
00:32:42,280 --> 00:32:47,120
Together, the Member States enable the best possible astronomical science

347
00:32:47,160 --> 00:32:49,640

at the world’s largest observatories.

348
00:32:55,040 --> 00:32:57,200
It’s good for their economies, too.

349
00:32:58,040 --> 00:33:02,640
ESO closely cooperates with industry, in both Europe and Chile.

350
00:33:13,440 --> 00:33:15,840
Access roads had to be constructed.

351
00:33:16,760 --> 00:33:18,640
Mountain tops had to be levelled.

352
00:33:20,160 --> 00:33:23,200
The Italian industrial consortium AES

353
00:33:23,240 --> 00:33:27,440
built the main structure of the four VLT telescopes.

354
00:33:27,999 --> 00:33:32,560
Each telescope weighs in at some 430 tonnes.

355
00:33:34,240 --> 00:33:40,080
They also constructed the giant enclosures, each as high as a ten-storey building.

356
00:33:42,880 --> 00:33:47,999
The German glass company Schott produced the delicate VLT mirrors

357
00:33:48,000 --> 00:33:52,240
– over eight metres wide and just twenty centimetres thick.

358
00:33:53,400 --> 00:33:55,400
At REOSC in France,

359
00:33:55,400 --> 00:33:59,960
the mirrors were polished to a precision of a millionth of a millimetre,

360
00:33:59,960 --> 00:34:03,160
before they made the long journey to Paranal.

361
00:34:08,200 --> 00:34:12,040
Meanwhile, universities and research institutes across Europe

362
00:34:12,080 --> 00:34:15,720
developed sensitive cameras and spectrometers.

363

00:34:17,640 --> 00:34:20,400
ESO’s telescopes are built with taxpayers' money.

364
00:34:20,400 --> 00:34:21,800
Your money.

365
00:34:21,880 --> 00:34:24,880
And so you can take part in the excitement.

366
00:34:24,920 --> 00:34:30,080
For example, ESO’s website is a rich source of astronomical information,

367
00:34:30,120 --> 00:34:33,560
including thousands of beautiful pictures and videos.

368
00:34:35,800 --> 00:34:39,600
Also, ESO produces magazines, press releases,

369
00:34:39,640 --> 00:34:44,240
and video documentaries such as the one you’re watching right now.

370
00:34:46,480 --> 00:34:48,080
And throughout the world,

371
00:34:48,080 --> 00:34:53,880
the European Southern Observatory contributes to exhibitions and science fairs.

372
00:34:58,960 --> 00:35:03,560
Countless ways to participate in the discovery of the cosmos!

373
00:35:05,640 --> 00:35:08,960
Did you know that the names of the four VLT telescopes

374
00:35:08,960 --> 00:35:11,560
were thought up by a young Chilean girl?

375
00:35:12,240 --> 00:35:14,880
17-year old Jorssy Albanez Castilla

376
00:35:14,880 --> 00:35:19,840
suggested the names Antu, Kueyen, Melipal, and Yepun

377
00:35:19,880 --> 00:35:26,320
– meaning Sun, Moon, Southern Cross and Venus in the Mapuche language.

378
00:35:27,200 --> 00:35:31,320
Involving school children and students like Jorssy is important.

379
00:35:32,880 --> 00:35:36,160
That’s where ESO’s educational activities come in,

380
00:35:36,520 --> 00:35:39,800
like student exercises and school lectures.

381
00:35:41,960 --> 00:35:46,120
When the planet Venus passed in front of the Sun in 2004,

382
00:35:46,160 --> 00:35:50,560
a special programme was aimed at European students and teachers.

383
00:35:53,400 --> 00:35:58,000
And in 2009, during the International Year of Astronomy,

384
00:35:58,040 --> 00:36:02,880
ESO reached millions of school children and students all over the world.

385
00:36:02,880 --> 00:36:07,320
After all, today’s children are tomorrow’s astronomers.

386
00:36:12,320 --> 00:36:16,960
But in terms of outreach, nothing beats the Universe itself.

387
00:36:24,320 --> 00:36:26,800
Astronomy is a visual science.

388
00:36:26,800 --> 00:36:33,080
Images of galaxies, star clusters and stellar nurseries fire our imagination.

389
00:36:37,800 --> 00:36:39,320
When not doing science,

390
00:36:39,320 --> 00:36:44,080
ESO's telescopes are sometimes used for the Cosmic Gems Programme

391
00:36:44,080 --> 00:36:49,160
– taking pictures just for the purpose of education and public outreach.

392
00:36:57,000 --> 00:37:00,680
After all, a picture is worth a thousand words.

393
00:37:03,880 --> 00:37:08,320
The general public can even take part in creating these staggering images,

394
00:37:08,320 --> 00:37:11,000
through the Hidden Treasures competitions.

395
00:37:14,160 --> 00:37:20,560
Russian astronomy enthusiast Igor Chekalin won the competition in 2010.

396
00:37:22,080 --> 00:37:26,080
His marvellous images are based on real science data.

397
00:37:31,840 --> 00:37:34,840
Member states, industry and universities.

398
00:37:34,840 --> 00:37:37,640
By cooperating on all possible levels,

399
00:37:37,640 --> 00:37:42,640
ESO has become one of the most successful astronomy organisations in the world.

400
00:37:43,040 --> 00:37:48,040
And through its engagement with the public, you are invited to join the adventure.

401
00:37:48,080 --> 00:37:51,160
The Universe is yours to discover.

402
00:37:57,680 --> 00:38:04,480
Catching Light

403
00:38:09,920 --> 00:38:11,480
For half a century,

404
00:38:11,480 --> 00:38:16,880
the European Southern Observatory has showcased the splendour of the Universe.

405
00:38:23,040 --> 00:38:25,440
Starlight rains down on the Earth.

406
00:38:27,200 --> 00:38:30,400
Giant telescopes catch the cosmic photons,

407
00:38:30,440 --> 00:38:34,320
and feed them to state-of-the-art cameras and spectrographs.

408
00:38:37,160 --> 00:38:41,960
Today’s astronomical images are very different from those of the 1960s.

409
00:38:43,400 --> 00:38:46,520
When ESO began, back in 1962,

410
00:38:46,520 --> 00:38:50,480

astronomers used large photographic glass plates.

411
00:38:51,480 --> 00:38:56,120
Not very sensitive, imprecise, and hard to handle.

412
00:39:00,600 --> 00:39:04,280
What a difference today's electronic detectors have made!

413
00:39:04,960 --> 00:39:07,880
They catch almost every photon.

414
00:39:08,400 --> 00:39:11,200
The images are available instantaneously.

415
00:39:11,240 --> 00:39:13,320
And, most importantly,

416
00:39:13,320 --> 00:39:17,320
they can be processed and analyzed by computer software.

417
00:39:17,920 --> 00:39:21,600
Astronomy has truly become a digital science.

418
00:39:28,600 --> 00:39:31,120
ESO telescopes use some of the largest

419
00:39:31,160 --> 00:39:33,840
and most sensitive detectors in the world.

420
00:39:33,840 --> 00:39:40,840
The VISTA camera has no less than 16 of them, for a total of 67 million pixels.

421
00:39:43,080 --> 00:39:48,160
This huge instrument catches infrared light from cosmic dust clouds,

422
00:39:48,200 --> 00:39:49,520
newborn stars

423
00:39:49,520 --> 00:39:52,600
and distant galaxies.

424
00:39:59,880 --> 00:40:05,600
Liquid helium keeps the detectors at minus 269 degrees.

425
00:40:05,600 --> 00:40:09,320
VISTA takes an inventory of the southern sky,

426

00:40:09,320 --> 00:40:13,040
like an explorer surveying an unknown continent.

427
00:40:15,640 --> 00:40:19,080
The VLT Survey Telescope is another discovery machine,

428
00:40:19,120 --> 00:40:22,040
but this one works at visible wavelengths.

429
00:40:27,960 --> 00:40:31,880
Its camera, called OmegaCAM, is even larger.

430
00:40:32,520 --> 00:40:37,480
32 CCDs team up to produce spectacular images

431
00:40:37,480 --> 00:40:42,480
with a mind-boggling 268 million pixels.

432
00:40:44,680 --> 00:40:47,999
The field of view is one square degree

433
00:40:48,000 --> 00:40:51,360
– four times as large as the full Moon.

434
00:40:53,520 --> 00:40:58,040
OmegaCAM generates fifty gigabytes of data every night.

435
00:40:59,400 --> 00:41:02,160
And these are just gorgeous gigabytes.

436
00:41:05,800 --> 00:41:09,200
Survey telescopes like VISTA and the VST

437
00:41:09,200 --> 00:41:12,920
also mine the sky for rare and interesting objects.

438
00:41:13,360 --> 00:41:17,240
Astronomers then use the sheer power of the VLT

439
00:41:17,240 --> 00:41:20,880
to study these objects in exquisite detail.

440
00:41:23,320 --> 00:41:25,760
Each of the VLT’s four telescopes

441
00:41:25,760 --> 00:41:28,200
has its own set of unique instruments,

442
00:41:28,200 --> 00:41:31,200
each with its own particular strengths.

443
00:41:31,999 --> 00:41:39,200
Without these instruments, ESO's giant eye on the sky would be, well, blind.

444
00:41:40,280 --> 00:41:46,920
They have fanciful names like ISAAC, FLAMES, HAWK-I and SINFONI.

445
00:41:47,800 --> 00:41:52,400
Giant high-tech machines, each the size of a small car.

446
00:41:54,200 --> 00:41:55,760
Their purpose:

447
00:41:55,760 --> 00:42:00,920
to record the cosmic photons and recover every possible bit of information.

448
00:42:03,240 --> 00:42:07,840
All of the instruments are unique, but some are a little more special than others.

449
00:42:08,120 --> 00:42:14,360
For example, NACO here and SINFONI use the VLT's adaptive optics system.

450
00:42:17,920 --> 00:42:20,840
Lasers produce artificial stars

451
00:42:20,840 --> 00:42:24,600
that help astronomers to correct for atmospheric blurring.

452
00:42:30,760 --> 00:42:35,360
NACO's images are as sharp as if they were taken from outer space.

453
00:42:38,080 --> 00:42:43,720
And then there's MIDI, and AMBER. Two interferometric instruments.

454
00:42:45,160 --> 00:42:49,720
Here, light waves from two or more telescopes are brought together,

455
00:42:49,720 --> 00:42:53,120
as if they were captured by one giant, single mirror.

456
00:42:55,560 --> 00:42:56,920
The result:

457
00:42:57,320 --> 00:42:59,800
the sharpest views you can imagine.

458
00:43:03,760 --> 00:43:06,720
But astronomy is not only about taking images.

459
00:43:06,760 --> 00:43:08,480
If you’re after the details,

460
00:43:08,480 --> 00:43:12,400
you have to dissect the starlight and study its composition.

461
00:43:15,360 --> 00:43:19,080
Spectroscopy is one of astronomy’s most powerful tools.

462
00:43:24,800 --> 00:43:29,120
No wonder ESO boasts some of the world’s most advanced spectrographs,

463
00:43:29,160 --> 00:43:31,640
like the powerful X-Shooter.

464
00:43:32,240 --> 00:43:37,240
Images carry more beauty, but spectra reveal more information.

465
00:43:41,560 --> 00:43:42,840
Composition.

466
00:43:43,920 --> 00:43:45,160
Motions.

467
00:43:46,080 --> 00:43:47,360
Ages.

468
00:43:53,480 --> 00:43:58,000
The atmospheres of exoplanets, orbiting distant stars.

469
00:44:01,520 --> 00:44:05,680
Or newborn galaxies at the edge of the observable Universe.

470
00:44:09,480 --> 00:44:14,480
Without spectroscopy, we would just be explorers staring at a beautiful landscape.

471
00:44:14,920 --> 00:44:16,360
With spectroscopy,

472
00:44:16,360 --> 00:44:21,360
we learn about the landscape’s topography, geology, evolution and composition.

473
00:44:31,160 --> 00:44:32,999

And there’s one more thing.

474
00:44:36,999 --> 00:44:41,880
Despite its serene beauty, the Universe is a violent place.

475
00:44:43,920 --> 00:44:45,800
Things go bump in the night,

476
00:44:45,800 --> 00:44:49,640
and astronomers want to catch each and every event.

477
00:44:53,400 --> 00:44:58,680
Massive stars end their lives in titanic supernova explosions.

478
00:45:04,600 --> 00:45:07,480
Some cosmic detonations are so powerful

479
00:45:07,520 --> 00:45:11,040
that they briefly outshine their parent galaxy,

480
00:45:11,040 --> 00:45:16,240
flooding intergalactic space with invisible, high-energy gamma rays.

481
00:45:18,200 --> 00:45:24,120
Small robotic telescopes respond to automatic alerts from satellites.

482
00:45:24,600 --> 00:45:30,800
Within seconds, they swing into position to study the aftermaths of these explosions.

483
00:45:32,120 --> 00:45:35,920
Other roboscopes focus on less dramatic events,

484
00:45:35,920 --> 00:45:40,000
such as distant planets that pass in front of their mother stars.

485
00:45:42,800 --> 00:45:46,400
The cosmos is in a constant state of flux.

486
00:45:46,440 --> 00:45:50,080
ESO tries not to miss a single heartbeat.

487
00:45:51,999 --> 00:45:55,999
Cosmology is the study of the Universe as a whole.

488
00:45:56,000 --> 00:46:00,440
Its structure, evolution and origin.

489

00:46:04,360 --> 00:46:08,960
Here, catching as much light as possible is of the essence.

490
00:46:09,320 --> 00:46:14,640
These galaxies are so far away that only a handful of photons reach the Earth.

491
00:46:17,080 --> 00:46:20,520
But these photons hold clues to the cosmic past.

492
00:46:22,320 --> 00:46:24,760
They have travelled for billions of years.

493
00:46:25,160 --> 00:46:28,840
They paint a picture of the early days of the Universe.

494
00:46:29,240 --> 00:46:34,160
That's why big telescopes and sensitive detectors are so important.

495
00:46:35,320 --> 00:46:37,440
Over the past fifty years,

496
00:46:37,440 --> 00:46:41,920
ESO telescopes have revealed some of the most distant galaxies and quasars

497
00:46:41,920 --> 00:46:43,960
ever observed.

498
00:46:47,360 --> 00:46:51,320
They even helped to uncover the distribution of dark matter,

499
00:46:51,360 --> 00:46:53,920
the nature of which is still a mystery.

500
00:47:00,560 --> 00:47:04,360
Who knows what the next fifty years will bring?

501
00:47:10,320 --> 00:47:15,000
Finding Life

502
00:47:17,520 --> 00:47:20,480
Have you ever wondered about life in the Universe?

503
00:47:20,480 --> 00:47:23,600
Inhabited planets orbiting distant stars?

504
00:47:23,600 --> 00:47:26,520
Astronomers have – for centuries.

505
00:47:26,520 --> 00:47:30,960
After all, with so many galaxies, and each with so many stars,

506
00:47:30,960 --> 00:47:33,160
how could the Earth be unique?

507
00:47:34,520 --> 00:47:39,120
In 1995, Swiss astronomers Michel Mayor and Didier Queloz

508
00:47:39,120 --> 00:47:43,680
were the first to discover an exoplanet orbiting a normal star.

509
00:47:44,000 --> 00:47:48,480
Since then, planet hunters have found many hundreds of alien worlds.

510
00:47:48,480 --> 00:47:53,800
Large and small, hot and cold, and in a wide variety of orbits.

511
00:47:54,600 --> 00:47:58,800
Now, we're on the brink of discovering Earth's twin sisters.

512
00:47:59,040 --> 00:48:04,840
And in the future: a planet with life – the Holy Grail of astrobiologists.

513
00:48:11,560 --> 00:48:15,080
The European Southern Observatory plays an important role

514
00:48:15,080 --> 00:48:17,320
in the search for exoplanets.

515
00:48:18,200 --> 00:48:22,560
Michel Mayor's team found hundreds of them from Cerro La Silla,

516
00:48:22,560 --> 00:48:25,880
ESO's first Chilean foothold.

517
00:48:26,680 --> 00:48:28,880
Here's the CORALIE spectrograph,

518
00:48:28,880 --> 00:48:32,120
mounted on the Swiss Leonhard Euler Telescope.

519
00:48:33,840 --> 00:48:39,800
It measures the tiny wobbles of stars, caused by the gravity of orbiting planets.

520
00:48:40,000 --> 00:48:46,520
ESO's venerable 3.6-metre telescope is also hunting for exoplanets.

521
00:48:47,760 --> 00:48:51,320
The HARPS spectrograph is the most accurate in the world.

522
00:48:51,320 --> 00:48:55,560
So far, it has discovered more than 150 planets.

523
00:49:00,600 --> 00:49:02,360
Its biggest trophy:

524
00:49:02,360 --> 00:49:08,680
a rich system containing at least five and maybe as many as seven alien worlds.

525
00:49:20,160 --> 00:49:22,560
But there are other ways to find exoplanets.

526
00:49:30,760 --> 00:49:37,360
In 2006, the 1.5-metre Danish telescope helped to discover a distant planet

527
00:49:37,360 --> 00:49:40,360
that is just five times more massive than the Earth.

528
00:49:44,160 --> 00:49:48,160
The trick? Gravitational microlensing.

529
00:49:48,880 --> 00:49:54,160
The planet and its parent star passed in front of a brighter star in the background,

530
00:49:54,160 --> 00:49:56,320
magnifying its image.

531
00:49:58,120 --> 00:50:03,280
And in some cases, you can even capture exoplanets on camera.

532
00:50:06,720 --> 00:50:13,240
In 2004, NACO, the adaptive optics camera on the Very Large Telescope,

533
00:50:13,240 --> 00:50:17,240
took the first image ever of an exoplanet.

534
00:50:17,240 --> 00:50:23,040
The red dot in this image is a giant planet orbiting a brown dwarf star.

535
00:50:26,560 --> 00:50:31,640
In 2010, NACO went one step further.

536
00:50:33,160 --> 00:50:37,320

This star is 130 light-years away from Earth.

537
00:50:37,320 --> 00:50:43,600
It is younger and brighter than the Sun, and four planets circle around it in wide orbits.

538
00:50:45,720 --> 00:50:50,960
NACO’s eagle-eyed vision made it possible to measure the light of planet c

539
00:50:50,960 --> 00:50:55,480
– a gas giant ten times more massive than Jupiter.

540
00:50:56,840 --> 00:50:59,440
Despite the glare of the parent star,

541
00:50:59,440 --> 00:51:03,440
the feeble light of the planet could be stretched out into a spectrum,

542
00:51:03,440 --> 00:51:06,400
revealing details about the atmosphere.

543
00:51:08,080 --> 00:51:14,680
Today, many exoplanets are discovered when they transit across their parent stars.

544
00:51:14,760 --> 00:51:18,040
If we happen to see the planet’s orbit edge-on,

545
00:51:18,040 --> 00:51:21,400
it will pass in front of its star every cycle.

546
00:51:21,400 --> 00:51:25,880
Thus, tiny, regular brightness dips in the light of a star

547
00:51:25,880 --> 00:51:29,320
betray the existence of an orbiting planet.

548
00:51:31,760 --> 00:51:36,600
The TRAPPIST telescope at La Silla will help search for these elusive transits.

549
00:51:37,240 --> 00:51:38,560
Meanwhile,

550
00:51:38,560 --> 00:51:45,120
the Very Large Telescope has studied a transiting planet in exquisite detail.

551
00:51:45,920 --> 00:51:53,840
Meet GJ1214b, a super-Earth 2.6 times larger than our home planet.

552

00:51:55,920 --> 00:52:01,800
During transits, the planet’s atmosphere partly absorbs the light of the parent star.

553
00:52:06,080 --> 00:52:11,760
ESO’s sensitive FORS spectrograph revealed that GJ1214b

554
00:52:11,760 --> 00:52:16,000
might well be a hot and steamy sauna world.

555
00:52:18,600 --> 00:52:23,080
Gas giants and sauna worlds are inhospitable to life.

556
00:52:23,080 --> 00:52:25,840
But the hunt is not over yet.

557
00:52:26,800 --> 00:52:31,640
Soon, the new SPHERE instrument will be installed at the VLT.

558
00:52:31,680 --> 00:52:37,080
SPHERE will be able to spot faint planets in the glare of their host stars.

559
00:52:38,400 --> 00:52:44,120
In 2016, the ESPRESSO spectrograph will arrive at the VLT

560
00:52:44,120 --> 00:52:48,120
and greatly surpass the current HARPS instrument.

561
00:52:49,760 --> 00:52:53,840
And ESO’s Extremely Large Telescope, once completed,

562
00:52:53,840 --> 00:52:57,800
may well find evidence for alien biospheres.

563
00:53:05,160 --> 00:53:08,080
On Earth, life is abundant.

564
00:53:09,720 --> 00:53:18,200
Northern Chile offers its share of condors, vicuñas, vizcachas and giant cacti.

565
00:53:20,680 --> 00:53:25,320
Even the arid soil of the Atacama desert teems with hardy microbes.

566
00:53:29,600 --> 00:53:33,960
We’ve found the building blocks of life in interstellar space.

567
00:53:35,000 --> 00:53:37,800
We’ve learnt that planets are abundant.

568
00:53:41,800 --> 00:53:46,840
Billions of years ago, comets brought water and organic molecules to Earth.

569
00:53:49,240 --> 00:53:52,960
Wouldn’t we expect the same thing to happen elsewhere?

570
00:53:58,440 --> 00:54:00,200
Or are we alone?

571
00:54:01,800 --> 00:54:03,840
It’s the biggest question ever.

572
00:54:05,160 --> 00:54:08,200
And the answer is almost within reach.

573
00:54:18,697 --> 00:54:24,816
Building Big

574
00:54:29,320 --> 00:54:32,240
Astronomy is big science.

575
00:54:34,800 --> 00:54:36,817
It’s a vast Universe out there,

576
00:54:36,842 --> 00:54:41,000
and the exploration of the cosmos requires huge instruments.

577
00:54:45,760 --> 00:54:50,519
This is the 5-metre Hale reflector on Palomar Mountain.

578
00:54:50,544 --> 00:54:55,470
When the European Southern Observatory came into being, fifty years ago,

579
00:54:55,495 --> 00:54:58,600
it was the largest telescope in the world.

580
00:55:00,175 --> 00:55:05,455
ESO’s Very Large Telescope at Cerro Paranal is the state of the art now.

581
00:55:06,299 --> 00:55:09,212
As the most powerful observatory in history,

582
00:55:09,237 --> 00:55:13,080
it has revealed the full splendour of the Universe in which we live.

583
00:55:15,720 --> 00:55:20,089
But astronomers have set their sights on even bigger instruments.

584
00:55:20,114 --> 00:55:23,360
And ESO is realising their dreams.

585
00:55:37,822 --> 00:55:40,142
San Pedro de Atacama.

586
00:55:41,424 --> 00:55:45,410
Tucked amidst breathtaking scenery and natural wonders,

587
00:55:45,435 --> 00:55:49,484
this picturesque town is home to indigenous Atacameños

588
00:55:49,509 --> 00:55:52,040
and adventurous backpackers alike.

589
00:55:54,280 --> 00:55:58,080
And ESO astronomers and technicians.

590
00:56:03,400 --> 00:56:07,696
Not far from San Pedro, ESO's first dream machine is taking shape.

591
00:56:07,721 --> 00:56:13,080
It's called ALMA – the Atacama Large Millimeter/submillimeter Array.

592
00:56:14,160 --> 00:56:19,491
ALMA is a joint project of Europe, North America and East Asia.

593
00:56:19,889 --> 00:56:23,057
It operates like a giant zoom lens.

594
00:56:23,082 --> 00:56:28,076
Close together, the 66 antennas provide a wide-angle view.

595
00:56:28,101 --> 00:56:33,838
But spread apart, they reveal much finer detail over a smaller area of sky.

596
00:56:35,760 --> 00:56:40,643
At submillimetre wavelengths, ALMA sees the Universe in a different light.

597
00:56:40,668 --> 00:56:42,120
But what will it reveal?

598
00:56:43,663 --> 00:56:49,160
The birth of the very first galaxies in the Universe, in the wake of the Big Bang.

599
00:56:51,880 --> 00:56:54,746

Cold and dusty clouds of molecular gas

600
00:56:54,771 --> 00:56:58,600
– the stellar nurseries where new suns and planets are born.

601
00:57:02,200 --> 00:57:04,760
And: the chemistry of the cosmos.

602
00:57:08,560 --> 00:57:13,560
ALMA will track down organic molecules – the building blocks of life.

603
00:57:17,680 --> 00:57:21,480
Construction of the ALMA antennas is in full swing.

604
00:57:22,440 --> 00:57:26,095
Two giant transporters, called Otto and Lore,

605
00:57:26,120 --> 00:57:30,101
take the completed antennas up to the Chajnantor Plateau.

606
00:57:36,200 --> 00:57:38,286
At 5000 metres above sea level,

607
00:57:38,311 --> 00:57:42,399
the array provides an unprecedented view of the microwave Universe.

608
00:57:49,662 --> 00:57:51,688
While ALMA is nearly completed,

609
00:57:51,713 --> 00:57:55,961
ESO’s next dream machine is still a few years away.

610
00:57:55,986 --> 00:57:57,868
See that mountain over there?

611
00:57:57,893 --> 00:58:00,160
That’s Cerro Armazones.

612
00:58:02,320 --> 00:58:04,048
Not far from Paranal,

613
00:58:04,073 --> 00:58:09,286
it will be home to the largest telescope in the history of mankind.

614
00:58:09,659 --> 00:58:14,080
Meet the European Extremely Large Telescope.

615

00:58:14,520 --> 00:58:17,240
The world’s biggest eye on the sky.

616
00:58:22,000 --> 00:58:25,500
Sporting a mirror almost forty metres across,

617
00:58:25,525 --> 00:58:30,465
the E-ELT simply dwarfs every telescope that preceded it.

618
00:58:32,838 --> 00:58:36,198
Almost eight hundred computer-controlled mirror segments.

619
00:58:37,917 --> 00:58:41,930
Complex optics to provide the sharpest possible images.

620
00:58:44,510 --> 00:58:47,317
A dome as tall as a church steeple.

621
00:58:52,520 --> 00:58:56,844
The E-ELT is an exercise in superlatives.

622
00:59:00,167 --> 00:59:04,647
But the real wonder, or course, is in the Universe out there.

623
00:59:10,120 --> 00:59:14,415
The E-ELT will reveal planets orbiting other stars.

624
00:59:18,160 --> 00:59:22,384
Its spectrographs will sniff the atmospheres of these alien worlds,

625
00:59:22,409 --> 00:59:24,520
looking for biosignatures.

626
00:59:28,320 --> 00:59:33,969
Further away, the E-ELT will study individual stars in other galaxies.

627
00:59:33,994 --> 00:59:38,480
It’s like meeting the inhabitants of neighbouring cities for the first time.

628
00:59:39,706 --> 00:59:42,181
Working as a cosmic time machine,

629
00:59:42,206 --> 00:59:45,845
the giant telescope lets us look back billions of years,

630
00:59:45,870 --> 00:59:47,800
to learn how everything began.

631
00:59:51,680 --> 00:59:55,461
And it may solve the riddle of the accelerating Universe

632
00:59:55,486 --> 00:59:59,955
– the mysterious fact that galaxies are pushed away from each other

633
00:59:59,980 --> 01:00:02,040
faster and faster.

634
01:00:13,960 --> 01:00:18,320
Astronomy is big science, and it’s a science of big mysteries.

635
01:00:18,628 --> 01:00:20,195
Is there life beyond Earth?

636
01:00:20,354 --> 01:00:22,160
What's the origin of the Universe?

637
01:00:23,358 --> 01:00:28,345
ESO’s new monster telescope will help in our quest to understand.

638
01:00:28,370 --> 01:00:31,994
We’re not there yet, but it won’t take long.

639
01:00:32,400 --> 01:00:33,720
So what’s next?

640
01:00:33,720 --> 01:00:35,550
Well, no one knows.

641
01:00:35,575 --> 01:00:38,360
But ESO is ready for the adventure.