1
00:00:00,080 --> 00:00:02,830
Houston, station on two.

2
00:00:02,830 --> 00:00:11,390
I'm Don Pettit and I'm on the
International Space Station.

3
00:00:11,390 --> 00:00:14,520
I'm one of the lucky guys
that get to fly in space.

4
00:00:14,520 --> 00:00:24,760
I use my off-duty time to investigate
scientific curiosities of my own design.

5
00:00:24,760 --> 00:00:34,540
So what you're going to see is a series
of my own investigations that I do simply

6
00:00:34,540 --> 00:00:42,030
because I am here, and I can, and these things
tickle my imagination and enrich my mind,

7
00:00:42,030 --> 00:00:49,690
and I'm hoping that they
will do the same for you.

8
00:00:49,690 --> 00:00:56,070
Okay, I'm working once again with
stretched, thin films of water.

9
00:00:56,070 --> 00:01:01,400
And you may these on a loop not unlike
you'd make a soap film with on Earth,

10
00:01:01,400 --> 00:01:05,370
but these are made with pure
water with no surfactant.

11

00:01:05,370 --> 00:01:11,420
And as far as I know these cannot be made in the
presence of significant gravitational forces.

12
00:01:11,420 --> 00:01:12,670
They break.

13
00:01:12,670 --> 00:01:19,640
And once you make these films, there's a bunch
of delightful things you can do with them.

14
00:01:19,640 --> 00:01:21,990
I'm going to oscilliate a
little bit - look at that.

15
00:01:21,990 --> 00:01:25,590
Really some wild things you can do.

16
00:01:25,590 --> 00:01:33,360
And that's because these films are thick
compared to soap film and there's more mass

17
00:01:33,360 --> 00:01:38,040
in the film and you can get this inertial
mass moving in a weightless environment.

18
00:01:38,040 --> 00:01:40,270
So... Oh, look at that.

19
00:01:40,270 --> 00:01:42,840
You can even spall off little drops.

20
00:01:42,840 --> 00:01:46,620
Let's see if I can do that, and then
you can capture them back again.

21
00:01:46,620 --> 00:01:49,420
Oh look at that, I spalled off
a drop, I'm going to capture it.

22
00:01:49,420 --> 00:01:51,410
There. Okay.

23
00:01:51,410 --> 00:01:53,410
Spall off a drop.

24
00:01:54,440 --> 00:01:55,230
Oh, two drops.

25
00:01:55,230 --> 00:01:56,570
And I'm going to capture the drop.

26
00:01:56,570 --> 00:01:59,400
I'm going to capture the drop.

27
00:01:59,400 --> 00:02:00,230
Oh look at that.

28
00:02:00,230 --> 00:02:01,050
It bounced off.

29
00:02:01,050 --> 00:02:03,290
There, we captured it.

30
00:02:03,290 --> 00:02:08,760
So, you can use them as sort
of a liquid drum head,

31
00:02:08,760 --> 00:02:14,100
to shoot other water droplets
at and look at the behavior.

32
00:02:14,100 --> 00:02:17,270
And here's a Teflon needle
hooked up to a syringe,

33
00:02:17,270 --> 00:02:20,390
and I'm squirting

water at one of these films.

34
00:02:20,390 --> 00:02:27,000
And some of the droplets bounce off, some
of the droplets get assimilated in the film,

35
00:02:27,000 --> 00:02:30,510
and some of the droplets actually go
through the film and jet out the other side.

36
00:02:30,510 --> 00:02:34,410
So, there's a lot of really
neat physics going on here.

37
00:02:34,410 --> 00:02:38,400
I'm still in the process of
trying to sort it all out.

38
00:02:38,400 --> 00:02:40,590
And then I'm putting tracer particles in these.

39
00:02:40,590 --> 00:02:43,320
And these are white ones,
white tracer particles.

40
00:02:43,320 --> 00:02:49,690
Going to put a couple of drops of these
in, and then get some convection going here

41
00:02:49,690 --> 00:02:54,090
which stirs these particles around, and
then wait for all the fluid motion to stop.

42
00:02:54,090 --> 00:02:57,610
So here we have a stationary pattern,

43
00:02:57,610 --> 00:03:00,540
and I'm taking the soldering iron
that we have on space station.

44
00:03:00,540 --> 00:03:06,780
And I'm putting that tip close to the
wireframe, and it adds a heat source,

45
00:03:06,780 --> 00:03:10,770
and that heat source changes the
surface tension next to the wire,

46
00:03:10,770 --> 00:03:17,590
and the surface tension forces then get in a
tug of war and they incite this convection,

47
00:03:17,590 --> 00:03:20,370
the fluid motion you are seeing here.

48
00:03:20,370 --> 00:03:25,730
And this is known as Marangoni convection.

49
00:03:25,730 --> 00:03:28,740
Now notice the direction of the convection here.

50
00:03:28,740 --> 00:03:37,050
It's going from the center of the film to the
edge of the wire where the heat source is.

51
00:03:37,050 --> 00:03:42,960
And we will see something really neat here.

52
00:03:42,960 --> 00:03:46,860
It looks just like the other one,
but it is significantly different.

53
00:03:46,860 --> 00:03:51,940
The last set up, the water
film was slightly thicker

54
00:03:51,940 --> 00:03:54,950
in the center than at the edge of the wire.

55
00:03:54,950 --> 00:04:00,290
So the films were convex, and the
fluid motion went from the center

56
00:04:00,290 --> 00:04:02,910
of the film to the edge of the wire.

57
00:04:02,910 --> 00:04:07,620
So here I have a film that is concave.

58
00:04:07,620 --> 00:04:12,810
So it's thinner in the center
and thicker at the edges.

59
00:04:12,810 --> 00:04:16,960
The convection is indeed reversed.

60
00:04:16,960 --> 00:04:21,020
So here we see an example
of Marangoni convection

61
00:04:21,020 --> 00:04:30,100
where you have a convexed fluid surface and
the fluid goes from the heat source away.

62
00:04:30,100 --> 00:04:34,290
When we had a convex surface,
it went towards the heat source.

63
00:04:34,290 --> 00:04:34,910
Now watch this.

64
00:04:34,910 --> 00:04:37,820
This is a really interesting example.

65
00:04:37,820 --> 00:04:42,990
Look at the violent nature of that convection.

66

00:04:42,990 --> 00:04:49,320
And now we're going to actually touch the tip
of the soldering iron to the fluid film itself.

67
00:04:49,320 --> 00:04:53,220
And again look at the intensity of
the convection that results from that.

68
00:04:53,220 --> 00:04:56,700
And this one seems to be kind of stuck closed.

69
00:04:56,700 --> 00:05:00,880
Let me just let go of this and see what happens.

70
00:05:00,880 --> 00:05:07,810
And let me open up my bag, and that loop
got caught up in a breeze, and it is going.