Jellyfish flames on the ISS

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Fire is inanimate, yet anyone staring into a flame could be excused for thinking otherwise: Fire dances and swirls. It reproduces, consumes matter, and produces waste. It adapts to its environment. It needs oxygen to survive.

In short, fire is uncannily lifelike.

Nowhere is this more true than onboard a spaceship.

Unlike flames on Earth, which have a tear-drop shape caused by buoyant air rising in a gravitational field, flames in space curl themselves into tiny balls. Untethered by gravity, they flit around as if they have minds of their own. More than one astronaut conducting experiments for researchers on Earth below has been struck by the way flameballs roam their test chambers in a lifelike search for oxygen and fuel.

Biologists confirm that fire is not alive. Nevertheless, on August 21st, astronaut Reid Wiseman on the ISS witnessed some of the best mimicry yet.

"It was a jellyfish of fire," he tweeted to Earth along with a video. Wiseman was running an experiment called FLEX-2, short for Flame Extinguishment Experiment 2. The goal of the research is to learn how fires burn in microgravity and, moreover, how to put them out. It's a basic safety issue: If fire ever breaks out onboard a spacecraft, astronauts need to be able to control it. Understanding the physics of flameballs is crucial to zero-G firefighting.

"Combustion in microgravity is both strange and wonderful," says Forman Williams, the PI of FLEX-2 from UC San Diego. "The 'jellyfish' phenomenon Wiseman witnessed is a great example."

He points out some of the key elements of the video:

"Near the beginning we see two needles dispensing a droplet mixture of heptane and iso-octane between two igniters. The fuel is ignited … then the lights go out so we can see what happens next."

"The flame forms a blue spherical shell 15 to 20 mm in diameter around the fuel. Inside that spherical flame we see some bright yellow hot spots. Those are made of soot."

Heptane produces a lot of soot as it burns, he explains. Consisting mainly of carbon with a sprinkling of hydrogen, soot burns hot, around 2000 degrees K, and glows brightly as a result.

"Several globules of burning soot can be seen inside the sphere," he continues. "At one point, a blob of soot punctures the flame-sphere and exits. The soot that exits fades away as it burns out."

There is also an S-shaped object inside the sphere. "That is another soot structure," he says.

The 'jellyfish phase' is closely linked to the production of soot. Combustion products from the spherical flame drift back down onto the fuel droplet. Because sooty material deposited on the droplet is not perfectly homogeneous, "we can get a disruptive burning event," says Forman. In other words, soot on the surface of the fuel droplet catches fire, resulting in a lopsided explosion.

Remarkably, none of this is new to Forman, who has been researching combustion physics since the beginning of the Space Age. "We first saw these disruptive burning events in labs and microgravity drop towers more than 40 years ago," he says. "The space station is great because the orbiting lab allows us to study them in great detail."

"Tom Avedisian at Cornell is leading this particular study," Forman says. "We're learning about droplet burning rates, the soot production process, and how soot agglomerates inside the flame."

At the end of Wiseman's video, the soot ignites in a final explosion. That's how the fire put itself out.

"It was a warp-drive finish," says Wiseman.

Provided by NASA