Creating the Elemental Vortex in Avatar: Fire and Ash

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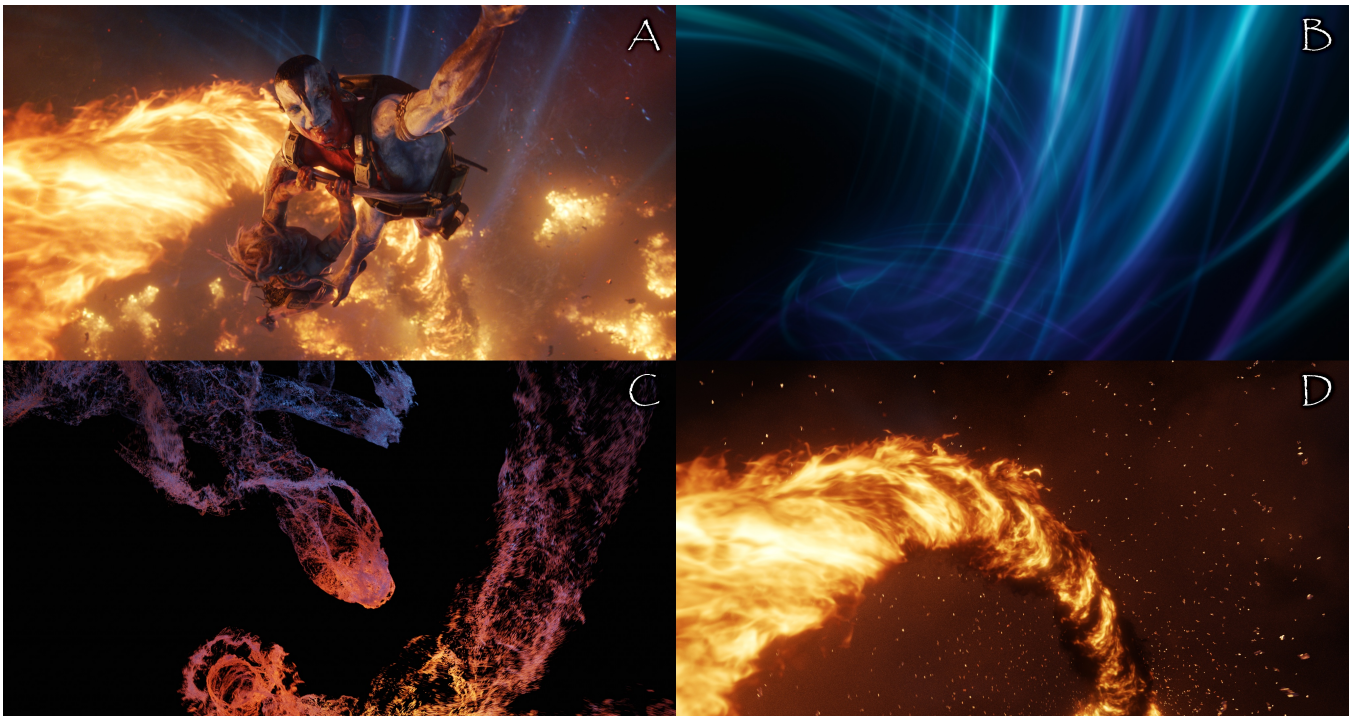

Figure 1: A Flux Devil shot from *Avatar: Fire and Ash* (a) and the elements it is composed of: plasma (b), water (c), and fire (d). ©2025 20th Century Studios / Lightstorm Entertainment. All Rights Reserved. ©2026 Wētā FX Ltd.

Abstract

The Flux Devil, an elemental vortex with a strong magnetic field in *Avatar: Fire and Ash*, is made up of plasma, water, and, in the climactic sequence, fire, see Figure 1. This talk covers building the individual elements and combining them into a cohesive whole.

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1 Motivation

The *Cove of the Ancestors* environment features an intricate gravity-defying double helix, where water is drawn up due to intense locally-occurring magnetic fields. The magnetic fields also react with the atmosphere, producing vibrant colors of purple, cyan and teal. Because metal objects are highly attracted to the Flux Devil, during the third act many destroyed crafts are drawn into it, exploding and trapping fire and debris within the double helix vortex.

Everything we set out to achieve on Avatar projects is deeply grounded in physics. When presented with the Flux Devil we knew we would have to have a mix of physical and fantastical. We started with reference artwork and templates along with drawing inspiration from various physical phenomena, such as fire and water in

zero gravity, wind-induced upside-down waterfalls, and fire tornadoes in forest fires.

To cater to the production requirements of several hundred shots, we had multiple Flux Devil scenarios that required different recipes and representations, ranging from being inside the Flux Devil, with water, plasma, fire and debris streaming past camera, to calm wide shots where you can see the ocean being drawn up into the helix far off in the distance.

2 Plasma

The plasma component of the Flux Devil had a few different design aesthetics, from intricate ethereal atmospheric bursting pulses to grabbing metal objects, while forking and branching on contact, see Figure 1(b) and Figure 2. We were inspired both by artwork and physical reference. The artwork gave us strong cues for the double helix structure and a teal, cyan and purple colour palette. For the atmospheric motion we drew inspiration from Aurora Borealis/Australis and for the contact branching we referenced plasma globes. We achieved the look using curve geometry rendered as ribbons with a purpose-built VEX material for the feathering and pulses, as well as several layers of particle simulations rasterized into emissive volumes. Beauty passes of the plasma were rendered in Mantra, with a separate geometry representation provided to our in-house render engine Manuka for interactive lighting in the rest of the scene.

3 Water

The water component had a variety of challenges, such as the connection—a swirling whirlpool at the base of the Flux—and the mist and spray being drawn up into an intricate double helix, splashing off rocks and forming clouds high above the Cove of the Ancestors, see Figure 1(c) and Figure 2. To support the demand of hundreds of Flux Devil shots, we broke the different required scenarios down into categories dependent on distance from camera and hero-interaction requirements: (i) shots inside the Flux, meaning we did not see the water connection and misty whirlpool, and the main focus was the intricate spirals flying past camera, splashing off rocks; (ii) wide shots where we could see more of the double helix structure but not the whirlpool base; (iii) wide shots where we could see the misty whirlpool connection and the double helix; (iv) shots that required interaction with bespoke pieces of animation. These categories were also shared within the plasma setups. For categories (i) to (iii) we assetised a significant amount, building a pre-cached library of assets that could be dropped into any number of shots depending on the required recipe. Much of the water itself was simulated using Pahi [Stomakhin et al. 2023].

Figure 2: At the ocean level the Flux Devil draws the water upward forming a helix-shaped mist skirt. ©2025 20th Century Studios / Lightstorm Entertainment. All Rights Reserved.

4 Fire

When the 700ft factory ship explodes at the base of the Flux Devil in the climactic sequence of the movie, the flames, together with the unburnt fuel, get sucked into the vortex along the magnetic lines, forming a 1000ft-tall column of fire. The director's vision for the effect was something akin to a fire tornado, but it needed to rotate slowly with fire exhibiting laminar rather than turbulent features. The combustion also had to persist at higher altitudes, implying fuel presence throughout the whole structure.

The formation of such a fantastical effect can be achieved via guiding with carefully crafted velocity fields. Velocity guiding methods, however, tend to be overly constraining, since they are based on the idea of overwriting parts of the simulated field with a prescribed one, erasing salient flow features and leading to loss of dynamic detail and ultimately sacrificing believability. Our goal instead was to create the most immersive and realistic experience for the viewers as possible, even in such an otherworldly scenario. We therefore adopted the philosophy of making the effect as physically justifiable as we could manage and turned our attention to real-world fire tornadoes.

At the core of a fire tornado is a strong updraft caused by burn, expansion and consequently buoyancy of the hot combustion products. Since buoyancy is a phenomenon manifested relative to typically colder and denser surroundings, and we needed to maintain a uniform fire structure of the column throughout its length, the buoyancy causes needed to be supernatural. We painted a stronger gravity field in the vicinity of the helix, which led to amplified buoyancy effects, creating a powerful updraft.

For the spinning part we drew inspiration from cyclones / anticyclones. Those occur at atmospheric scales and are caused by Coriolis forces associated with the rotation of the Earth. We implemented a truncated variant of Coriolis acceleration $\boldsymbol{a} = \omega \times \boldsymbol{v}$, ignoring non-local terms, where $\boldsymbol{v}$ is the velocity of the simulated flow and ω is an artist-specified angular velocity field. The magnitude of ω controls the amount of spinning, and we ended up using values much higher than the Earth's angular velocity in order to achieve the desired effect at the helix's smaller than atmospheric scale.

The simulation was performed within our in-house framework Loki [Lesser et al. 2022], with fuel emitted along the center line of the column, and the result can be seen in Figure 1(d).

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