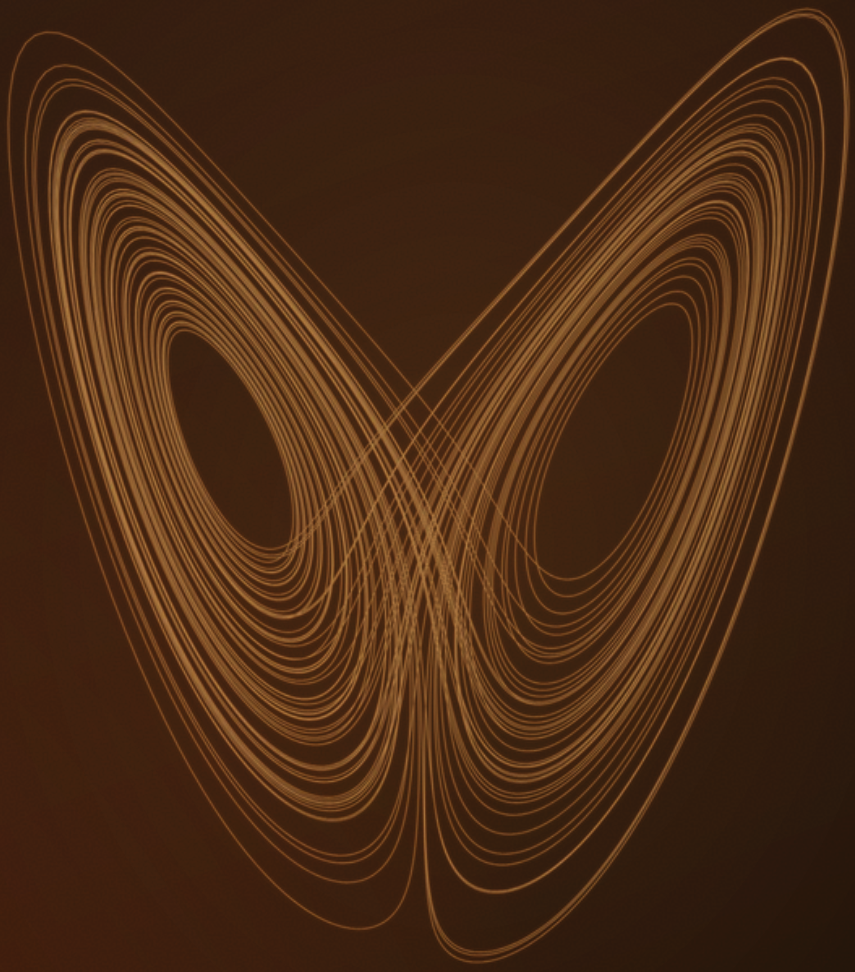
USER MANUAL · VERSION 1.0



WAVE CHAOS

Chaotic-oscillator synthesizer. Five strange attractors, eight voices.

MODEL	FORMATS	PLATFORMS	VERSION
MOD. ET-7	VST3 · AU · Standalone	macOS · Windows	1.0

ERIC TRIPPER

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01 The audio model

Differential equations, integrated in real time, heard as sound.

Most synthesizers start from a waveform: a stored table, a sawtooth, a sine. WaveChaos starts from a small system of differential equations. Each voice contains a point moving through three-dimensional space according to those equations. WaveChaos computes the position of that point at every audio sample and sends its coordinates to the speakers. What you hear is the shape of the motion.

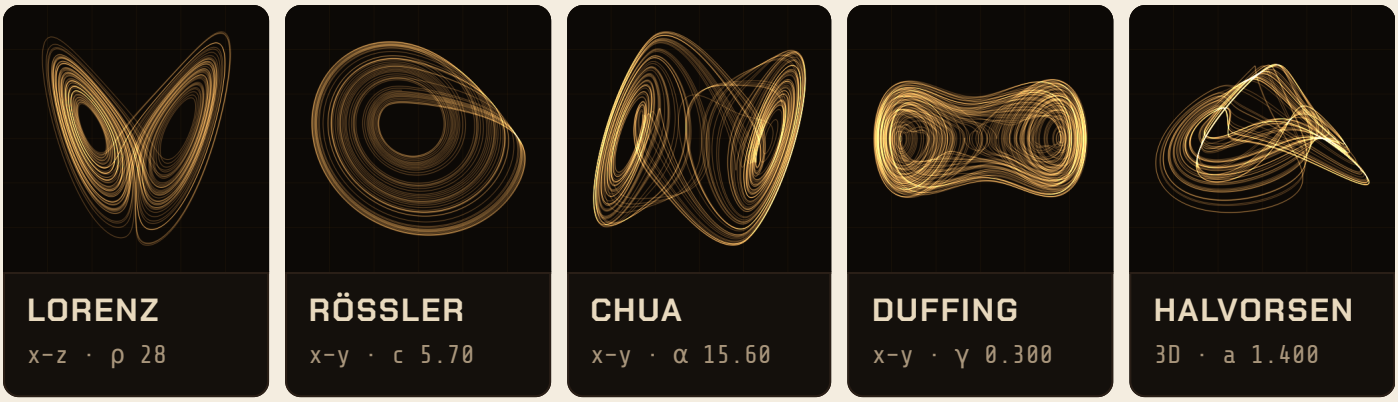
The systems used are *chaotic*: the point never repeats exactly the same path, yet it stays inside a bounded, recognisable shape. The result is a tone with a clear pitch whose waveform keeps changing in small, unpredictable ways. Turning the **Chaos** control moves each system from nearly periodic motion, which sounds almost like a classic oscillator, to fully turbulent motion, which sounds rough, noisy and unstable.

1.1 Strange attractors in brief

A system of ordinary differential equations (ODEs) tells you, for any position `(x, y, z)`, in which direction and how fast the point moves next. Start the point somewhere and follow these instructions step by step, and you get a *trajectory*.

In a dissipative system the trajectory soon settles onto a limited region called an *attractor*. For a simple oscillator the attractor is a closed loop: the point goes round and round, and the sound is a steady periodic wave. In a chaotic system the attractor is a *strange attractor*. It has a fine, folded structure, the point loops around it forever without closing the loop, and two trajectories that start very close together drift apart quickly. This sensitivity to initial conditions is why two notes played on WaveChaos never sound exactly alike, and why the **Reseed** function (`Shift` + `FREEZE`) gives you a new variation of the same sound.

Each loop around the attractor takes roughly the same time. That is what gives a chaotic oscillator a perceivable pitch. The variations from one loop to the next give it its life: subtle jitter at low Chaos settings, rough sub-harmonics and noise at high settings.



These portraits are computed when the page opens, with the same equations and constants as the synthesizer, at the parameter value shown under each one.

1.2 The five systems

WaveChaos contains five classic chaotic systems. Each has fixed constants and one parameter controlled by **Chaos**. The Chaos control runs from 0 to 100 % and maps linearly onto the range given below. The screen shows the real parameter value, for example ρ 44.5 for Lorenz at the default 30 %.

Two more values matter for how each system becomes sound. The **natural period** T_0 is the approximate time, in the system's own time units, that the point takes to go once around the attractor. WaveChaos uses it to set the playing speed (section 1.3). The **pitch axis** is the coordinate whose oscillation best follows that loop. Auto-tune counts its cycles (section 1.5).

LORENZ Edward Lorenz, 1963 · convection model

$$\begin{aligned} dx/dt &= \sigma\,(y - x) \\ dy/dt &= x\,(\rho - z) - y \\ dz/dt &= x\,y - \beta\,z \end{aligned} \qquad \sigma = 10,\ \ \beta = 8/3$$

CHAOS PARAMETER	NATURAL PERIOD T_0	PITCH AXIS	MAX. STEP
ρ 25 → 90	0.754	z	0.008

The famous two-winged butterfly. The point circles one wing, then at irregular moments jumps to the other. The z coordinate rises and falls once per loop on either wing, so it carries the pitch cleanly. The x and y coordinates change sign with every jump between wings, which adds an irregular, lower-frequency square-like component. Higher ρ makes the attractor larger and the motion more agitated.

RÖSSLER Otto Rössler, 1976 · single-band spiral

$$\begin{aligned} dx/dt &= -y - z \\ dy/dt &= x + a\,y \\ dz/dt &= b + z\,(x - c) \end{aligned} \qquad a = b = 0.2$$

CHAOS PARAMETER	NATURAL PERIOD T_0	PITCH AXIS	MAX. STEP
c 2.5 → 12	5.854	x	0.03

A flat spiral in the x–y plane with an occasional excursion up the z axis that folds the trajectory back onto itself. x and y are close to sine waves; z is a train of sharp spikes. At the bottom of the range the orbit is periodic. As c rises the orbit splits into two loops, then four, then becomes chaotic. Each doubling adds energy one octave below the previous lowest component, so Rössler gives you a sub-octave cascade under the Chaos control.

CHUA Leon Chua, 1983 · electronic circuit with a nonlinear diode

$$\begin{aligned} dx/dt &= \alpha\,(y - x - g(x)) \\ dy/dt &= x - y + z \\ dz/dt &= -\beta\,y \end{aligned} \qquad \beta = 28$$

$$g(x) = m_1 \cdot x + \tfrac{1}{2}\,(m_0 - m_1)\,(|x + 1| - |x - 1|)$$

$$m_0 = -1.143, \quad m_1 = -0.714$$

CHAOS PARAMETER	NATURAL PERIOD T_0	PITCH AXIS	MAX. STEP
α 11 → 16	1.435	y	0.008

The model of a real analogue circuit built from capacitors, an inductor and a piecewise-linear resistor g(x), sometimes called the Chua diode. Its attractor is the "double scroll": two spirals joined at the middle. x switches between the two scrolls and sounds hard and buzzy. y is small and carries the pitch. z is smooth and wide. Chua is the most electric-sounding system in WaveChaos.

DUFFING Georg Duffing, 1918 · forced nonlinear spring

$$\dot{x} = y$$
$$\dot{y} = -\delta y + x - x^3 + \gamma \cos(z)$$
$$\dot{z} = 1 \qquad \delta = 0.25,\ \omega = 1 \text{ (z is the drive phase)}$$

CHAOS PARAMETER	NATURAL PERIOD T_0	PITCH AXIS	MAX. STEP
γ 0.2 → 0.7	2π	locked to the drive	0.04

A damped mass on a stiff spring with two stable resting points, pushed by a periodic force of strength γ. The third variable is the phase of that force. Because the force has a fixed period of 2π and WaveChaos runs exactly one force period per note period, the fundamental is locked to the note. The audio uses `cos(z)` as its Z coordinate, which is the drive sine itself: Duffing's Z axis is a clean sine at the played pitch. X and Y carry the chaotic response of the spring.

HALVORSEN cyclically symmetric system

$$\dot{x} = -a\,x - 4\,y - 4\,z - y^2$$
$$\dot{y} = -a\,y - 4\,z - 4\,x - z^2$$
$$\dot{z} = -a\,z - 4\,x - 4\,y - x^2$$

CHAOS PARAMETER	NATURAL PERIOD T_0	PITCH AXIS	MAX. STEP
a 1.27 → 2.1	1.56	x	0.008

The three equations are the same with x, y and z rotated. The attractor has three identical lobes, and the three coordinates have the same statistics. Moving the Axis control therefore changes the timbre without changing the level, and Stereo offset gives a balanced, wide image. The sound tends towards metal, bells and hard edges.

1.3 From trajectory to audio

INTEGRATION

The equations are solved numerically with the fourth-order Runge–Kutta method (RK4), the standard accurate method for this kind of problem. Each voice advances its trajectory

once per audio sample. When one step would be too large for the system to stay accurate, the step is divided into up to **16 sub-steps** per sample. Each system has a maximum step size (the "Max. step" values above); the number of sub-steps is the smallest that keeps every sub-step at or below it, capped at 16.

THE NOTE SETS THE SPEED

A trajectory has no pitch of its own: it only has a shape and a speed. WaveChaos chooses the speed so that the point travels one natural period T_0 per period of the note. The time advanced per sample is

$$h = T_0 \times f \times \text{correction} / \text{sample rate} \qquad f = \text{note frequency} \times \text{Tune}$$

Playing an octave higher doubles the speed, so the point goes round the attractor twice as often. The screen shows the current step and sub-step count on the `STEP` line, for example `h 0.0069 × 1 RK4`.

SYSTEM	T_0	MAX. STEP	SUB-STEPS AT A4 (440 HZ, 48 KHZ)	16-STEP CAP REACHED AT
Lorenz	0.754	0.008	1	≈ 8.1 kHz
Rössler	5.854	0.03	2	≈ 3.9 kHz
Chua	1.435	0.008	2	≈ 4.3 kHz
Duffing	2π	0.04	2	≈ 4.9 kHz
Halvorsen	1.56	0.008	2	≈ 3.9 kHz

The cap figures assume an Auto-tune correction of ×1 and a 48 kHz sample rate. Above the cap the step grows beyond the system's maximum, the integration becomes coarser and the timbre gets harsher. For normal playing ranges this never happens.

STARTING A VOICE

When a silent voice starts, it is placed near a known point on the attractor with a small random offset, then integrated for 400 steps without output so that it is already on the attractor when you hear it. For Duffing, the drive phase also starts at a random angle. The same happens to all sounding voices when you change Attractor or press Reseed. If a trajectory ever escapes (any coordinate beyond ±10 000), the voice is reseeded automatically.

NORMALISATION

The raw coordinates live on very different scales: Lorenz z sits around 40 with large swings, Chua y moves by a few tenths. Each voice therefore follows a running mean (time constant

0.3 s) and a running deviation (0.4 s) for each axis, and divides the centred value by 2.5 times the deviation. Every axis then reaches the audio stage at a similar level, whatever the system or the Chaos setting. The result is soft-clipped with a gentle `tanh` curve. The normalised values are also what the phase-space display draws.

AXIS AND STEREO OFFSET

The **Axis** control picks which coordinate you hear on the left channel, and morphs continuously between them in the order X → Y → Z → X. At 0.5 you hear an equal mix of X and Y; the display shows this as `X→Y 50%`. The right channel reads the attractor at *Axis + Stereo offset*. At 0 % offset both channels are identical. At 100 % the right channel is one full axis further on, so with Axis on X the left plays X and the right plays Y. Because the coordinates are different views of the same motion, the stereo image moves and breathes in a way that a simple detune cannot produce.

1.4 Why pitch drifts

The natural period T_0 is an average measured at typical settings. In a chaotic system the real loop time varies from loop to loop, and its average changes with the Chaos parameter. Raising ρ on Lorenz, for example, makes the point travel faster around a larger attractor. If the speed were only set by T_0, the perceived pitch would slide as you turn Chaos, and some systems would sit a few semitones off the note.

1.5 How Auto-tune works

With **Auto-tune** on (the default), every voice measures its own pitch while it plays:

1. It watches the normalised pitch axis of its system and counts *rising crossings*: each time the value goes above +0.12 after having been below −0.12. The two thresholds stop noise from producing false counts.
2. Every 200 ms it divides the count by the elapsed time to obtain the measured frequency. At least three crossings are needed for a valid measurement.
3. It compares the note frequency with the measurement and adjusts its speed factor by that ratio raised to the power 0.35. The correction converges over a few windows without overshooting. It is limited to the range `×0.25 … ×4`.
4. Each system keeps a shared learnt correction (70 % previous value, 30 % newest voice). New voices start from it, so they begin close to the right pitch.

The current correction is shown on the `PITCH` line of the screen and on page 2 (SHAPE).

DUFFING IS PITCH-LOCKED

Duffing is driven by an external sine whose period equals the note period, so its fundamental always matches the note. Auto-tune is never applied to it; the AUTO-TUNE indicator stays dark and the PITCH line shows `locked`.

AUTO-TUNE OFF

Switching Auto-tune off does not reset the correction to ×1. It freezes the correction at its last value. This is useful when you want the pitch to follow the raw dynamics of the system while you sweep Chaos, without the corrector pulling it back.

1.6 Inside the oscillator: Radiation, Fold, Sub

Radiation injects random noise directly into the state of the system, on the x variable, at every sample. The noise is scaled by the square root of the step size, as in a physical random process, so its effect stays consistent across pitches, and by a per-system factor so that the same setting has a comparable effect on each attractor. Because the noise enters the equations rather than the audio, it does not sound like added hiss. It pushes the trajectory off its usual path, which makes it switch lobes more often and adds grit and instability. The control has a square-law curve for fine adjustment at low values.

Fold is a sine wavefolder applied after the soft clip. As it rises it both blends in the folded signal and increases the folding gain (up to 7×), adding bright, metallic harmonics.

Sub −1 oct mixes a sine one octave below the note into both channels, while reducing the attractor signal by up to half. It gives weight and a stable fundamental under a chaotic tone.

1.7 Wander and Freeze

Wander is a slow, global modulation source shared by all voices. Its **shape** is either *Sine* or *Random*. Random picks a new value at every cycle and glides to it with a smooth cosine curve, so it never jumps. Its **target** is one of three destinations:

- **Chaos**: adds up to ±50 % of the Chaos range at full depth, clipped to 0–100 %.
- **Axis**: moves the Axis by up to ±1.5 positions, wrapping round X → Y → Z.
- **Fold**: adds up to ±50 % of Fold, clipped to 0–100 %.

FREEZE catches the sound you are hearing and holds it. Two things happen. The wander stops where it currently is. And each voice loops its orbit: at the next rising crossing of its pitch axis, the voice stores the exact position of its point, and every time the trajectory

reaches that crossing again it is sent back to the stored position. The attractor then repeats one lap of its orbit, so the waveform stops evolving and becomes a stable, periodic tone: a snapshot of the chaos, still in tune. Notes started while FREEZE is on capture their own orbit at their first crossing. Changing Chaos, Axis, Fold or the filter while frozen still changes the sound; Radiation and the input sample keep disturbing the frozen orbit. Press FREEZE again and the chaos runs free from where it is.

1.8 The input sample as a forcing term

You can load an audio file into WaveChaos (chapter 6). Its signal is added, sample by sample, to the right-hand side of the first equation of every voice (for Duffing, to the second, which is the force on the spring):

```
dx/dt = … + Input drive × k × input(t)      k: Lorenz 130, Rössler 11, Chua 12, Duffing 1.8, Halvorsen 34
```

The constant `k` scales the input to each system's size so that Input drive has a similar effect everywhere. The sample does not pass through the attractor like audio through a filter. It *pushes* the point. Small pushes bend the waveform and impose the rhythm and envelope of the sample onto the tone. Larger pushes knock the trajectory from one lobe to another, so transients in the sample trigger bursts of chaos. Because the system is nonlinear and sensitive, the same sample played twice does not give exactly the same result.

Two further controls use the sample directly. **Ring mod** multiplies each voice's filtered output by the sample. **Dry input** adds the sample itself to the mix after saturation, so it also goes to the echo and reverb.

1.9 After the oscillator: signal flow

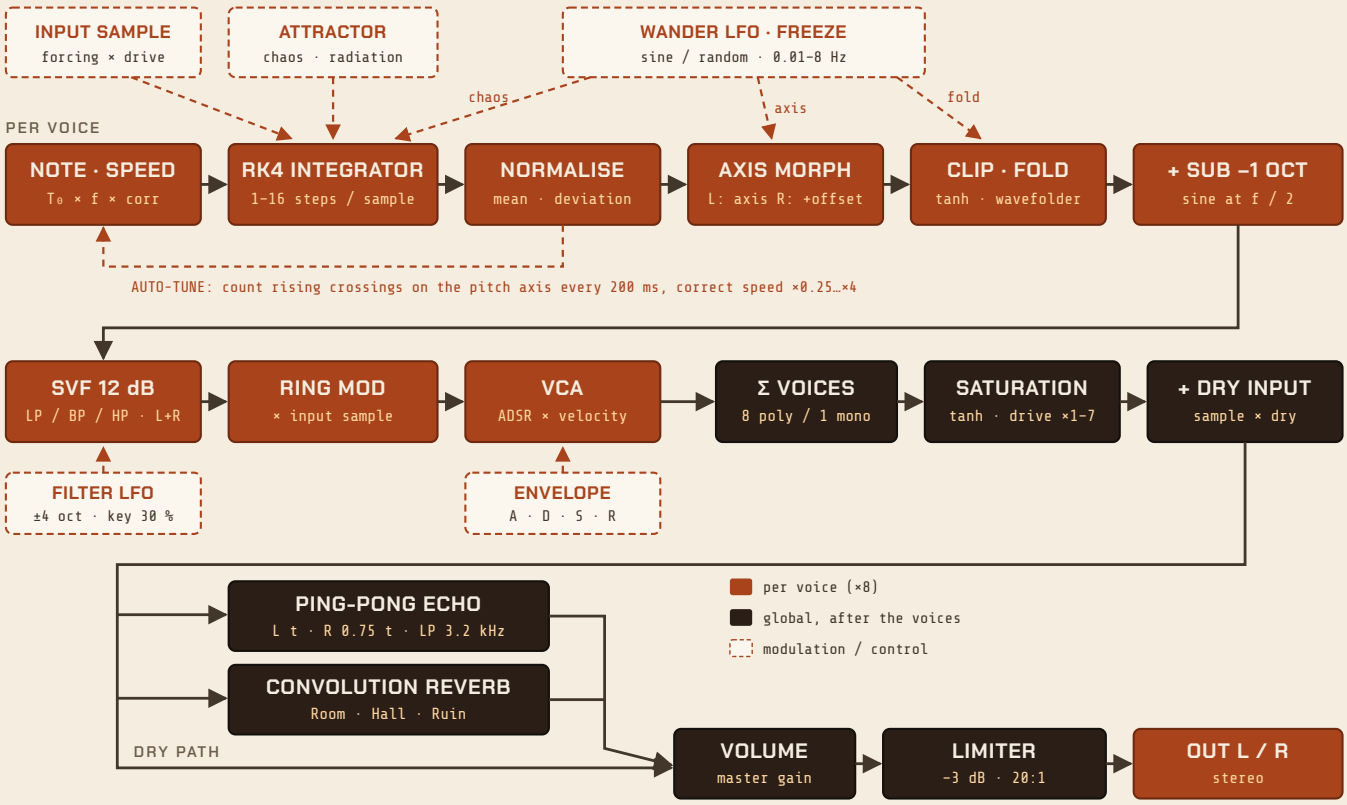


FIG. 1 Signal flow. The red blocks run separately in each voice, in stereo. The input sample feeds three places: the equations, the ring modulator and the dry path.

FILTER

Each voice has a state-variable filter (SVF) with a 12 dB/octave slope, one per channel, switchable between low-pass, band-pass and high-pass. Resonance runs from a gentle response to a sharp, ringing peak (Q of about 17 at 100 %). The cutoff is modulated by a global sine LFO over up to ±4 octaves, and follows the keyboard with a fixed 30 % key tracking referenced to middle C (261.6 Hz): one octave up the keyboard raises the cutoff by about 0.3 octave. The cutoff is kept between 20 Hz and 45 % of the sample rate.

RING MODULATOR AND VCA

When an input sample is playing, Ring mod multiplies the filtered signal by it. The VCA then applies the ADSR envelope and the note velocity. The attack is linear; decay and release are exponential and reach about 2 % of their starting distance in the set time.

SATURATION

The summed voices go through a `tanh` saturator with a drive from 1 to 7. Its output is normalised, so raising Saturation thickens the sound without a large jump in level.

ECHO

A stereo ping-pong delay fed by a send. The left delay uses the Echo time, the right uses 0.75 times that, which keeps the repeats from lining up. Each side feeds the other through a 3.2 kHz low-pass filter, so the repeats bounce across the stereo field and get darker as they fade. Feedback is limited to 92 %.

REVERB

A convolution reverb on a separate send. Its impulse response is filtered noise with a 60 dB decay over the length of the chosen space: `Room 1.2 s`, `Hall 3.4 s`, `Ruin 7.0 s`. Hall is the brightest of the three, Ruin the darkest. The impulse response is regenerated each time you change the type.

VOLUME AND LIMITER

The dry signal, echo and reverb are summed, scaled by Volume, and pass through a fast limiter (threshold −3 dB, ratio 20:1, 2 ms attack, 120 ms release) that protects your monitors from the sudden peaks chaotic systems can produce.

02 Quick start

From installation to your first chaotic patch in ten minutes.

01

Install and load

Install WaveChaos (chapter 9). In your DAW, create an instrument track and insert WaveChaos as its instrument. In the standalone version, click anywhere on the instrument to start the audio: the red AUDIO OFF indicator disappears.

02

Play a note

Play your MIDI keyboard or a MIDI clip. The phase-space display draws the trajectory of the last voice played, and the oscilloscope on the right shows the output waveform. You hear the default patch *Init*: a Lorenz attractor at ρ 44.5.

03

Turn Chaos

Page 1 (SYSTEM) is shown. Turn **encoder 2** (Chaos) slowly down to 0 %, then up to 100 %. Watch the attractor shape and listen to the tone move from smooth to rough.

04

Change the attractor

Click the names in the ATTRACTOR row under the display, or turn encoder 1. Try each of the five systems with the same note.

05

Change what you hear

Turn encoder 3 (Axis) through X, Y and Z. Each axis is a different voice of the same motion. Turn encoder 4 (Stereo offset) up for a wider image.

06

Hold a drone

Press the red **DRONE** button. WaveChaos holds the drone note (A2 by default) so you can adjust parameters with both hands. Press it again to stop.

07

Open the presets

Click PRESETS at the top right of the screen and pick a factory sound, for example *Shelter 7* or *Dead Turbine*. Then press **PAGE** to step through the nine pages and see how it is built.

08

Feed it a sound

Drag an audio file (a drum loop works well) onto the screen. WaveChaos jumps to page 9 (INPUT) with the input in Loop mode. Hold a note and raise Input drive: the loop now pushes the attractor around.

RESET ANY CONTROL

Double-click an encoder tile on the screen to return that parameter to its default value.

03 The front panel

One 1024 × 600 screen, four encoders, four buttons.

WaveChaos is designed like a hardware instrument. A rusted steel panel holds a 1024 × 600 amber screen, four push-buttons on the right and four encoders below. Everything is reached through nine pages of four parameters each.



FIG. 2 The instrument panel. Numbers refer to the list below.

1. **Top bar.** Preset name, attractor and voice mode, current page, status indicators, PRESETS button.
2. **Phase-space display.** The trajectory of the last voice played.
3. **Oscilloscope and readouts.** Output waveform and live engine values.
4. **Mode row.** Selectors and meters that belong to the current page.
5. **Encoder tiles.** The four parameters of the current page, one above each encoder.
6. **Page tabs.** Click a tab to go to that page.

7 **DRONE** (red). Holds the drone note. With Shift: all notes off.

8 **PAGE.** Next page. With Shift: previous page.

9 **FREEZE** (amber). Freezes the sound: the wander holds and each voice loops its orbit. With Shift: reseed every voice.

10 **SHIFT.** Latches the second function.

11 **Encoders 1–4.** Each controls the tile above it.

3.1 The screen



FIG. 3 The screen in its default state (preset Init, page 1). Readout values are examples.

	ELEMENT	WHAT IT SHOWS
A	**Preset name**	Name of the last preset loaded. An asterisk (`Init *`) means a sound parameter has changed since. The line below shows the attractor and the voice mode (`POLY 8` or `MONO`).
B	**Page**	Current page number and name, for example `1/9 · SYSTEM`.
C	**Status indicators**	`AUDIO OFF` (standalone only, red outline): audio is not running yet; click the instrument or play a note. `AUTO-TUNE`: lit while Auto-tune is on and the attractor is not Duffing. `FREEZE`: lit while the sound is frozen. `SHIFT`: lit while Shift is latched. `DRONE`: lit red while the drone note is held. `SIZE` (plug-in only): steps the window through fixed sizes that fit your screen, from 50 % to 150 %; the size is saved with the project. `PRESETS`: opens and closes the preset browser.
D	**Phase-space display**	The trajectory of the most recently played voice, drawn from its normalised coordinates with an amber phosphor trail. The header shows the attractor and the view. Choose the view on page 1: `XY`, `XZ`, `YZ` or `3D` (slowly rotating; the rotation stops if your system asks for reduced motion). With no sound, a dim Lorenz demo is drawn with `NO SIGNAL · PLAY A NOTE` (or, before audio has started in the standalone, `AUDIO OFF · PLAY A NOTE OR PRESS DRONE`).
E	**Equation**	The equations of the current attractor.
F	**Oscilloscope**	The final stereo output (after the limiter), triggered on a rising zero crossing for a stable picture.
G	**Readouts**	`PARAM` the real Chaos parameter value, including wander. `STATE` the raw x, y, z of the last voice (for Duffing, z is shown as cos of the drive phase). `STEP` integration step h and the number of RK4 sub-steps per sample. `PITCH` the note frequency including Tune, with the Auto-tune correction (`×1.00`) or `locked` for Duffing. `VOICES` active voices out of 8 (poly) or 1 (mono). `INPUT` input mode and sample name, or `drop audio here`.
H	**Input waveform**	Appears when a sample is loaded. It turns amber, with a light playhead, while the sample is feeding the attractor.
I	**Mode row**	Changes with the page: selectors (click a segment to choose) and live meters. Described page by page in chapter 4.
J	**Encoder tile**	Parameter name, value and an arc showing the position in its range. The tile lights up while you turn its encoder. A `FINE` badge appears while Shift is latched.
K	**Encoder number**	Which hardware encoder controls the tile.

3.2 Encoders and tiles

Each encoder controls the tile directly above it. You can operate a parameter in several ways:

- **Drag** an encoder or its tile up or down with the mouse.
- **Scroll** the mouse wheel over an encoder.

- **Arrow keys**: click an encoder to focus it, then use ↑/→ to increase and ↓/← to decrease.
- **Click** a tile (without dragging) to step a selector to its next option, or a stepped value (Drone note, Keys octave) up by one. Both wrap round at the end.
- **Double-click** a tile to reset the parameter to its default.

The encoders accelerate: slow turns move in fine steps, fast turns cover the whole range quickly (up to 25 times faster). With Shift latched, continuous parameters move four times more finely and acceleration is ignored. **Tune** is special: it moves in whole semitones normally, and in 0.01-semitone steps with Shift. Selectors need two encoder steps per option, so they do not skip past the choice you want.

3.3 Buttons

BUTTON	PRESS	SHIFT + PRESS	KEY
DRONE RED	Starts or stops the drone: holds the Drone note (page 8) at full velocity. The LED and the DRONE indicator light while it plays.	All notes off: releases every voice, including the drone.	Space
PAGE	Next page (after 9 comes 1).	Previous page.	
FREEZE AMBER	Freezes the sound, or releases it: the wander stops where it is and every voice loops its current orbit (see section 1.7). The LED stays lit while frozen.	Reseed: restarts every sounding voice from new initial conditions on the attractor. The LED flashes briefly.	Enter / Shift + Enter
SHIFT	Latches Shift on (or off). A hint appears: `Drone = all off · Page = back · Freeze = reseed`.		

> **HOW SHIFT LATCHES**
> You do not hold Shift. Press it once, then press the second button: the combination runs and Shift switches off. While Shift is latched, the encoders work in fine mode and Shift stays on until you use it with a button or press SHIFT again.

> **THE PRESETS OVERLAY**
> The PRESETS button in the top bar covers the display with the preset browser (chapter 7). Click CLOSE, the PRESETS button again, or any page tab to return.

04 The nine pages

Thirty-six parameters, four at a time.

Ranges and defaults below are the values shown on the screen. A GLOBAL tag marks settings that belong to the instrument rather than to the sound: they are not stored in presets and do not change when you load one. All other parameters are part of the patch.

1 SYSTEM The attractor and how you hear it

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	**Attractor**	Lorenz · Rössler · Chua · Duffing · Halvorsen	Lorenz	The chaotic system. Changing it reseeds every sounding voice.
2	**Chaos**	0–100 %	30 %	The system's parameter, displayed as its real value: Lorenz ρ 25.0–90.0, Rössler c 2.50–12.00, Chua α 11.00–16.00, Duffing γ 0.200–0.700, Halvorsen a 1.270–2.100. MIDI CC1 controls it.
3	**Axis**	X → Y → Z → X	X	Which coordinate the left channel plays, with continuous morphing between neighbours (shown as X→Y 40%).
4	**Stereo offset**	0–100 %	25 %	How far ahead of Axis the right channel reads. 100 % is one full axis.

Mode row: ATTRACTOR selector (same as encoder 1) and VIEW selector for the display: XY, XZ, YZ, 3D (default 3D) GLOBAL.

At the default 30 %, Chaos gives ρ 44.5 (Lorenz), c 5.35 (Rössler), α 12.50 (Chua), γ 0.350 (Duffing), a 1.519 (Halvorsen).

2 SHAPE Timbre inside the oscillator

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	**Fold**	0–100 %	15 %	Sine wavefolder: blend and folding gain rise together. Bright, metallic harmonics.
2	**Radiation**	0–100 %	0 %	Noise injected into the equations. Adds instability and grit rather than hiss. Square-law response for fine control at low values.
3	**Sub –1 oct**	0–100 %	20 %	Sine one octave below the note, mixed into both channels.
4	**Tune**	−12.00 to +12.00 st	0.00 st	Transposition in semitones. Whole steps normally; 0.01 st steps with Shift.

Mode row: AUTO-TUNE selector `Off` / `On` (default On), followed by a live line: pitch axis of the system, current correction and step, for example `Pitch axis z · correction ×1.00 · step h 0.0035 ×1`. With Duffing it reads `Duffing is driven by a sine: pitch locked, no correction needed`.

3 WANDER Slow drift

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	**Wander rate**	0.01–8.0 Hz	0.15 Hz	Speed of the wander. Logarithmic. With Random shape, the rate at which new values are chosen.
2	**Wander depth**	0–100 %	20 %	Amount. At 100 %: ±50 % Chaos, ±1.5 Axis positions, or ±50 % Fold.
3	**Wander target**	Chaos · Axis · Fold	Chaos	The destination.
4	**Wander shape**	Sine · Random	Sine	Sine: smooth cycle. Random: a new random value each cycle, reached with a smooth glide.

Mode row: SHAPE and TARGET selectors, a meter showing the wander's current position around its centre, and `FROZEN · orbit and wander held · press Freeze to release` while FREEZE is on. The frozen state is not part of the patch.

4 FILTER State-variable filter

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	Cutoff	40 Hz–16.0 kHz	3.00 kHz	Filter frequency. Logarithmic. Follows the keyboard at a fixed 30 %. MIDI CC74 controls it.
2	Resonance	0–100 %	30 %	Emphasis at the cutoff, up to a sharp ringing peak.
3	LFO → cutoff	Off, ±0.0–4.0 oct	Off	Depth of the sine LFO on the cutoff, in octaves either side.
4	LFO rate	0.02–20.0 Hz	0.50 Hz	LFO speed. Logarithmic. The LFO is shared by all voices.

Mode row: TYPE selector `Low-pass` / `Band-pass` / `High-pass` (default Low-pass), a meter that follows the LFO when it is on, and a caption.

5 ENV Amplitude envelope

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	Attack	1 ms–4.00 s	10 ms	Linear rise to full level.
2	Decay	10 ms–6.00 s	400 ms	Exponential fall to the sustain level.
3	Sustain	0–100 %	60 %	Level held while the key is down.
4	Release	10 ms–8.00 s	800 ms	Exponential fade after the key is released.

Mode row: eight voice cells, `V1` to `V8`, each with the note it is playing and a bar showing its envelope level. A voice in its release phase is drawn in a darker amber.

6 FX Echo and reverb

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	Echo time	20 ms–1.20 s	380 ms	Left delay time. The right side uses 75 % of it. Logarithmic.
2	Echo feedback	0–92 %	35 %	Amount of cross-feedback through the 3.2 kHz low-pass.
3	Echo mix	0–100 %	25 %	Send level to the echo.
4	Reverb mix	0–100 %	30 %	Send level to the reverb.

Mode row: REVERB selector `Room` / `Hall` / `Ruin` (default Hall) and a caption with the tail length: `1.2`, `3.4` or `7.0 s`.

7 OUTPUT Voices and level

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	**Voices**	`Poly 8 · Mono`	`Poly 8`	Eight-voice polyphony or one legato voice. Switching releases all notes.
2	**Glide**	`Off, 2 ms–2.00 s`	`Off`	Portamento time. Square-law control for precision at short times.
3	**Saturation**	`0–100 %`	`20 %`	Tanh drive on the summed voices.
4	**Volume** GLOBAL	`−∞ to +1.6 dB`	`−1.9 dB`	Master level before the limiter.

Mode row: VOICES selector, an output level meter (RMS, 60 dB range), and the voice count, for example `3 / 8 voices active`.

8 SETUP MIDI, drone and keyboard

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	**MIDI channel** GLOBAL	`Omni · 1–16`	`Omni`	Channel WaveChaos responds to. Omni accepts all channels.
2	**Velocity** GLOBAL	`0–100 %`	`60 %`	Velocity sensitivity. At 0 % every note plays at full level. At 60 %, the softest note plays at 40 %.
3	**Drone note**	`C1–C7`	`A2`	The note held by DRONE. Stored with the patch. A change applies the next time you start the drone.
4	**Keys octave** GLOBAL	`−3 to +3`	`0`	Octave of the computer keyboard (standalone).

Mode row: MIDI status and drone note, for example `MIDI from the host · drone A2 ON` in the plug-in. In the standalone version the status lists the names of the MIDI ports found, or reports that MIDI is unavailable or that access was refused.

9 INPUT The input sample

ENC	PARAMETER	RANGE	DEFAULT	FUNCTION
1	**Input** GLOBAL	Off · Loop · Gate	Off	How the loaded sample plays (chapter 6).
2	**Input drive** GLOBAL	0–100 %	30 %	Strength of the sample as a force in the equations.
3	**Ring mod** GLOBAL	0–100 %	0 %	Blend from the plain voice to the voice multiplied by the sample.
4	**Dry input** GLOBAL	0–100 %	0 %	Level of the sample itself in the output.

Mode row: INPUT selector, LOAD… button, CLEAR button (when a sample is loaded), an input level meter, and the sample name and length, for example `drumloop · 4.0 s`.

05 Playing

MIDI, voices, glide, velocity, drone, computer keyboard.

5.1 MIDI

In the plugin, WaveChaos receives notes from the host's MIDI track. In the standalone version it opens every MIDI input it finds on your system, and keeps the list up to date as you connect or disconnect devices. In both cases the **MIDI channel** setting on page 8 filters incoming messages.

MESSAGE	EFFECT
Note on / off	Plays and releases notes. Note on with velocity 0 counts as note off.
CC 1 (mod wheel)	Chaos, 0–127 over the full 0–100 % range.
CC 74	Cutoff, 0–127 over 40 Hz–16 kHz on the same logarithmic curve as the encoder.
CC 123	All notes off.

Other controllers, pitch bend and aftertouch are ignored.

5.2 Voices

Poly 8. Up to eight notes sound at once, each with its own trajectory, filter and envelope. Playing a note that is already sounding re-uses its voice. When all eight are busy, WaveChaos takes the quietest voice that is already releasing, or else the oldest voice. A voice that is re-used keeps its trajectory running and only the new pitch and envelope apply, so fast passages stay continuous.

Mono. One voice, last-note priority. Playing a new key while another is held changes the pitch without restarting the envelope (legato). Releasing it returns to the key still held, and the envelope releases when the last key goes up.

Glide (page 7) slides each new note from the pitch of the previously played note. It is an exponential glide: the set time is roughly the time to cover most of the interval. It works in both modes; in Poly mode each new voice glides from the last note played.

5.3 Velocity

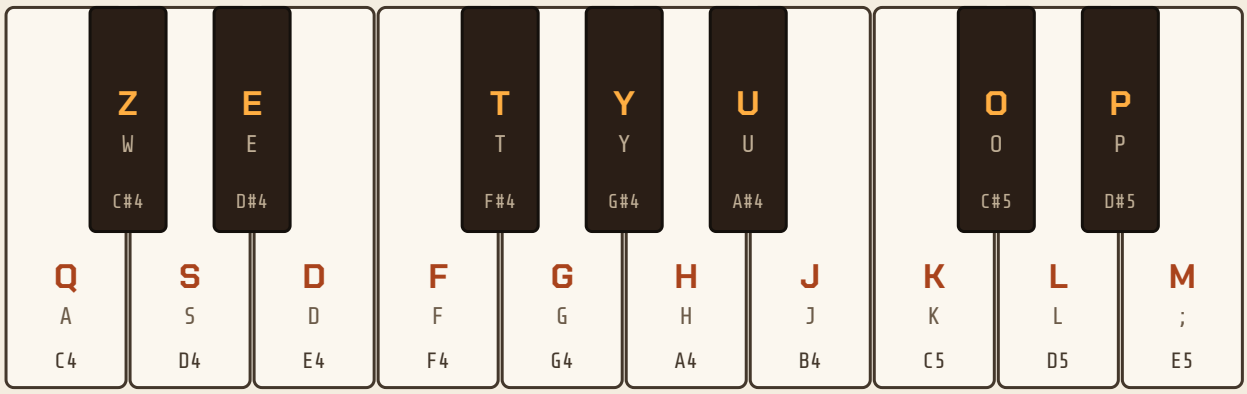
The level of a note is `1 - sensitivity × (1 - velocity)`. With the default 60 % sensitivity, a full-velocity note plays at 100 % and the softest note at 40 %. At 0 %, velocity is ignored. Velocity changes level only, not timbre.

5.4 Drone

DRONE (or `Space` in the standalone) holds the Drone note at full velocity until you press it again. It behaves like a held key, so you can play other notes over it in Poly mode. The drone note is stored with each preset: *Wasteland Drone* uses A1 and *Reactor Hum* uses E1. Loading a preset, Shift + DRONE and CC 123 release every note, including the drone.

5.5 Computer keyboard (standalone)

The standalone version can be played from the computer keyboard. Keys are read by *physical position*, so the layout is the same on every keyboard. The bottom of the range is C4 (middle C) at Keys octave 0. Computer-keyboard notes play at velocity 85 %, before velocity sensitivity is applied.



BIG LETTER = AZERTY · SMALL = QWERTY · NOTE AT KEYS OCTAVE 0

FIG. 4 Note keys. Ten white keys span C4 to E5; seven black keys give the sharps.

FUNCTION	AZERTY KEY	QWERTY KEY
White notes C4 D4 E4 F4 G4 A4 B4 C5 D5 E5	Q S D F G H J K L M	A S D F G H J K L ;
Black notes C#4 D#4 F#4 G#4 A#4 C#5 D#5	Z E T Y U O P	W E T Y U O P
Octave down / up (–3 to +3)	W / X	Z / X
Drone on / off	Space	Space
Freeze	Enter	Enter
Reseed	Shift + Enter	Shift + Enter

Keys are ignored while the preset-name field or an encoder has keyboard focus, and while `Ctrl`, `Alt` or `Cmd` is held. If the window loses focus, all computer-keyboard notes are released.

06 Processing your own sound

Use any audio file to push the attractors around.

An input sample turns WaveChaos into a processor for rhythm, texture and voice. The sample enters the equations as a force (section 1.8), so it shapes the motion of the trajectory instead of being filtered by it. You still play notes: the notes set the pitch and speed of the attractor, and the sample pushes it.

6.1 Loading a sample

- **Drag and drop** an audio file onto the instrument. A dashed frame with `DROP AUDIO TO FEED THE ATTRACTOR` confirms the drop target.
- Or go to page 9 and click `LOAD…` to choose a file.

Accepted formats are WAV, AIFF, MP3, OGG, FLAC and M4A, as far as your system can decode them. Stereo files are mixed to mono, the first 60 seconds are kept, and the level is normalised to a peak of 95 %. After loading, WaveChaos jumps to page 9, sets Input to Loop if it was Off, and shows the waveform under the readouts. `CLEAR` removes the sample.

> **IN THE PLUGIN**
> The loaded sample is saved with your DAW project, together with the patch, and is restored when you reopen the project.

6.2 Loop and Gate

MODE	BEHAVIOUR	USE IT FOR
Off	The sample is loaded but unused.	Comparing with and without the input.
Loop	The sample plays continuously in a loop, whether or not notes are held. It only affects the voices while they sound, but Dry input is heard all the time.	Steady textures, drones over a loop, free-running rhythms.
Gate	The sample plays only while at least one key is held, and restarts from the beginning when the first key goes down after all keys were released. Legato playing does not restart it. During the release phase the sample stops.	Playing the sample rhythmically from the keyboard, one-shots, vocal phrases.

6.3 The three input controls

Input drive sets how hard the sample pushes. Start low (10–30 %): the tone takes on the envelope and rhythm of the sample. Above about 50 % transients knock the trajectory between lobes, and the attractor's own pitch starts to break up. **Ring mod** multiplies the filtered voice by the sample: metallic, sideband-rich, and it imposes the sample's dynamics strictly. **Dry input** lets you hear the sample itself, through the echo and reverb.

6.4 Recipes

Drums into a bass

Duffing, Bunker Bass preset. Load a drum loop, Input Loop, drive 25 %, hold a low note. Kicks push the spring into its other well; the pitch stays locked.

Gated voice

Lorenz, Axis Z, Chaos 10 %. Load a spoken phrase, Input Gate, drive 40 %, Ring mod 30 %. Every chord you play speaks the phrase from the start.

Broken transmission

Chua, Broken Radio preset. Input Loop with a field recording, drive 60 %, Dry 15 %. Radiation and the input together make the double scroll jump constantly.

Rhythmic period doubling

Rössler, Chaos about 10 %, Axis X. Load a percussive loop at drive 20–35 %. Hits push the orbit in and out of its doubled loops, so sub-octaves appear on the beat.

Bell resonator

Halvorsen, Rust Bell preset, Input Gate. Feed it short plucks or claps, drive 30 %, Ring mod 20 %. Each hit excites the metallic lobes.

Ring-mod texture

Any system, Ring mod 100 %, Input drive 0 %. The attractor acts only as a chaotic carrier for the sample, much like a classic ring modulator with a living oscillator.

LEVEL

High Input drive with high Chaos can produce loud peaks. The output limiter catches them, but lower Volume on page 7 if you hear the limiter pumping.

07 Presets

28 factory sounds, and your own.

7.1 The preset browser

Click **PRESETS** in the top bar. The browser shows two grids: **FACTORY** and **USER PRESETS**. Each card shows the name and a short description; the current preset is outlined in amber. Click a card to load it. The browser closes and every sounding note is released.

A preset sets every patch parameter. Global settings (Volume, Velocity, MIDI channel, Keys octave, View, and the four Input controls) are not affected. The FREEZE state is not part of a preset either.

7.2 Saving your own

1. Open the browser.
2. Type a name (up to 40 characters) in the field at the bottom.
3. Click **SAVE** or press `Enter`.

The new preset appears under USER PRESETS, with its attractor as description. Saving under an existing name replaces that preset. There is no delete command: to tidy the list, overwrite unwanted presets with new sounds.

> **WHERE USER PRESETS LIVE**
>
> In the plugin, user presets are saved with the DAW project. In the standalone version they are stored on your computer and are available every time you open it.

7.3 Factory presets

The tables give the main settings of each factory preset as they appear on the screen. Parameters not listed are at their defaults. The "Screen label" column is the description shown on the preset card.

LORENZ

PRESET	SCREEN LABEL	CHAOS	FILTER	A / D / S / R	OTHER SETTINGS
Shelter 7	Lorenz pad	ρ 28.9	LP 1.80 kHz, res 25 % LFO ±0.3 oct @ 0.12 Hz	1.20 s / 2.00 s / 80 % / 3.00 s	Axis Z · Fold 5 % · Sub 15 % · Wander Chaos, sine 0.08 Hz, 12 % · Hall 60 %
Nuclear Dawn	Lorenz swell	ρ 60.8	LP 2.60 kHz, res 40 % LFO ±0.4 oct @ 0.08 Hz	2.50 s / 3.00 s / 70 % / 5.00 s	Axis Y→Z 40% · Fold 20 % · Radiation 2 % · Sub 25 % · Wander Chaos, sine 0.05 Hz, 50 % · Ruin 80 %
Fallout Choir	Lorenz wide pad	ρ 34.8	LP 2.20 kHz, res 30 % LFO ±0.2 oct @ 0.18 Hz	1.80 s / 2.50 s / 85 % / 4.00 s	Axis Y→Z 50% · Fold 10 % · Sub 10 % · Wander Axis, sine 0.12 Hz, 25 % · Ruin 70 %
Ash Fall	Lorenz slow random	ρ 44.5	LP 1.60 kHz, res 35 % LFO ±0.3 oct @ 0.38 Hz	2.00 s / 3.00 s / 80 % / 5.00 s	Axis Z→X 50% · Fold 20 % · Sub 20 % · Wander Chaos, random 0.25 Hz, 55 % · Ruin 65 %
Dust Devil	Lorenz high-pass swirl	ρ 73.8	HP 900 Hz, res 40 % LFO ±0.3 oct @ 1.4 Hz	300 ms / 1.20 s / 70 % / 1.80 s	Axis X→Y 40% · Fold 30 % · Radiation 10 % · Wander Axis, sine 0.90 Hz, 50 % · Hall 50 %
Cold Spring	Lorenz clean tone	ρ 25.0	LP 5.00 kHz, res 10 % LFO ±0.3 oct @ 0.15 Hz	20 ms / 1.00 s / 60 % / 1.50 s	Axis Z · Sub 10 % · Wander Chaos, sine 0.10 Hz, 0 % · Hall 45 %
Meltdown	Lorenz chaos sweep	ρ 57.5	LP 3.50 kHz, res 60 % LFO ±0.4 oct @ 0.09 Hz	500 ms / 2.00 s / 80 % / 3.00 s	Axis X→Y 90% · Fold 45 % · Radiation 20 % · Sub 20 % · Wander Chaos, sine 0.06 Hz, 100 % · Ruin 60 %
Init	Default Lorenz	ρ 44.5	LP 3.00 kHz, res 30 %	10 ms / 400 ms / 60 % / 800 ms	Axis X · Fold 15 % · Sub 20 % · Wander Chaos, sine 0.15 Hz, 20 % · Hall 30 %

RÖSSLER

PRESET	SCREEN LABEL	CHAOS	FILTER	A / D / S / R	OTHER SETTINGS
Acid Rain	Rössler pluck	c 7.73	LP 5.20 kHz, res 45 % LFO ±0.7 oct @ 2.4 Hz	5 ms / 350 ms / 30 % / 600 ms	Axis X · Fold 35 % · Radiation 5 % · Sub 10 % · Wander Chaos, sine 1.6 Hz, 30 % · Hall 35 %
Wasteland Drone	Rössler drone	c 4.40	LP 1.40 kHz, res 60 %	3.00 s / 2.00 s / 100 % / 6.00 s	Axis Z→X 20% · Fold 30 % · Sub 40 % · Wander Axis, random 0.03 Hz, 60 % · Ruin 75 % · Drone note A1
Mutant Lead	Rössler mono lead	c 6.30	LP 3.80 kHz, res 50 % LFO ±0.6 oct @ 7.5 Hz	10 ms / 400 ms / 75 % / 350 ms	Axis X · Fold 30 % · Sub 20 % · Wander Chaos, sine 5.0 Hz, 8 % · Hall 30 % · Mono, glide 120 ms
Glow Worm	Rössler soft keys	c 3.64	LP 2.40 kHz, res 20 % LFO ±0.5 oct @ 0.45 Hz	5 ms / 900 ms / 35 % / 1.10 s	Axis Y · Fold 5 % · Sub 15 % · Wander Chaos, sine 0.30 Hz, 10 % · Hall 40 %
Scavenger	Rössler fold bass	c 9.15	LP 1.50 kHz, res 45 % LFO ±0.7 oct @ 0.75 Hz	3 ms / 350 ms / 45 % / 200 ms	Axis X · Fold 60 % · Sub 45 % · Wander Fold, sine 0.50 Hz, 20 % · Room 10 % · Mono, glide 30 ms
Night Watch	Rössler slow arp	c 5.35	LP 2.80 kHz, res 45 % LFO ±0.8 oct @ 0.22 Hz	4 ms / 600 ms / 10 % / 900 ms	Axis Y→Z 60% · Fold 20 % · Sub 10 % · Wander Axis, sine 0.15 Hz, 30 % · Hall 55 %

CHUA

PRESET	SCREEN LABEL	CHAOS	FILTER	A / D / S / R	OTHER SETTINGS
Geiger	Chua noise lead	α 15.25	LP 7.00 kHz, res 55 % LFO ±1.0 oct @ 6.3 Hz	1 ms / 120 ms / 10 % / 200 ms	Axis Y · Fold 60 % · Radiation 25 % · Wander Chaos, random 4.2 Hz, 25 % · Room 20 %
Siren Field	Chua band-pass	α 13.00	BP 1.10 kHz, res 75 % LFO ±0.4 oct @ 0.52 Hz	400 ms / 1.50 s / 70 % / 2.00 s	Axis Y→Z 70% · Fold 10 % · Wander Chaos, sine 0.35 Hz, 70 % · Hall 55 %
Static Storm	Chua noise wash	α 16.00	LP 6.00 kHz, res 20 % LFO ±0.1 oct @ 3.8 Hz	800 ms / 1.00 s / 90 % / 2.50 s	Axis X→Y 50% · Fold 40 % · Radiation 60 % · Wander Chaos, random 2.5 Hz, 50 % · Ruin 60 %
Broken Radio	Chua band-pass jitter	α 14.00	BP 1.80 kHz, res 70 % LFO ±0.3 oct @ 5.0 Hz	10 ms / 600 ms / 60 % / 400 ms	Axis Y→Z 20% · Fold 25 % · Radiation 35 % · Wander Axis, random 3.3 Hz, 40 % · Room 25 %
Signal Lost	Chua ghost pad	α 12.25	BP 2.00 kHz, res 55 % LFO ±0.1 oct @ 0.11 Hz	2.20 s / 3.00 s / 80 % / 6.00 s	Axis Z→X 40% · Fold 5 % · Radiation 15 % · Wander Chaos, random 0.07 Hz, 65 % · Ruin 80 %

DUFFING

PRESET	SCREEN LABEL	CHAOS	FILTER	A / D / S / R	OTHER SETTINGS
Dead Turbine	Duffing bass	Y 0.425	LP 700 Hz, res 50 % LFO ±0.8 oct @ 0.30 Hz	4 ms / 500 ms / 50 % / 300 ms	Axis X · Fold 25 % · Sub 50 % · Wander Chaos, sine 0.20 Hz, 35 % · Room 15 % · Mono, glide 80 ms
Bunker Bass	Duffing mono bass	Y 0.325	LP 420 Hz, res 35 % LFO ±1.0 oct @ 0.15 Hz	2 ms / 300 ms / 60 % / 150 ms	Axis X · Fold 10 % · Sub 65 % · Wander Chaos, sine 0.10 Hz, 0 % · Room 5 % · Mono, glide 40 ms
Iron Lung	Duffing breathing pad	Y 0.500	LP 1.30 kHz, res 45 % LFO ±0.2 oct @ 0.27 Hz	1.40 s / 2.00 s / 90 % / 3.00 s	Axis Y · Fold 20 % · Sub 30 % · Wander Chaos, sine 0.18 Hz, 60 % · Hall 50 %
Reactor Hum	Duffing sub drone	Y 0.375	LP 500 Hz, res 50 %	2.50 s / 2.00 s / 100 % / 5.00 s	Axis X · Fold 15 % · Sub 80 % · Wander Chaos, sine 0.04 Hz, 40 % · Ruin 45 % · Drone note E1
Geiger Tick	Duffing perc	Y 0.550	LP 8.00 kHz, res 30 % LFO ±1.3 oct @ 1.5 Hz	1 ms / 70 ms / 0 % / 100 ms	Axis Y · Fold 40 % · Radiation 30 % · Wander Chaos, sine 1.0 Hz, 20 % · Room 25 %

HALVORSEN

PRESET	SCREEN LABEL	CHAOS	FILTER	A / D / S / R	OTHER SETTINGS
Scrapyard	Halvorsen metal	a 1.851	LP 4.20 kHz, res 35 % LFO ±0.5 oct @ 0.90 Hz	20 ms / 800 ms / 45 % / 1.20 s	Axis X→Y 60% · Fold 45 % · Radiation 10 % · Sub 5 % · Wander Axis, sine 0.60 Hz, 40 % · Hall 45 %
Rust Bell	Halvorsen bell	a 1.560	LP 9.00 kHz, res 20 % LFO ±0.8 oct @ 0.30 Hz	1 ms / 1.80 s / 0 % / 2.20 s	Axis Z · Fold 55 % · Wander Chaos, sine 0.20 Hz, 10 % · Hall 55 %
Tin Can Arp	Halvorsen pluck	a 1.727	LP 3.20 kHz, res 55 % LFO ±1.1 oct @ 0.60 Hz	1 ms / 180 ms / 0 % / 250 ms	Axis X→Y 30% · Fold 50 % · Wander Chaos, sine 0.40 Hz, 15 % · Room 25 %
Sawblade	Halvorsen hard lead	a 2.017	LP 6.50 kHz, res 40 % LFO ±0.4 oct @ 8.0 Hz	2 ms / 300 ms / 80 % / 250 ms	Axis Y · Fold 75 % · Sub 10 % · Wander Chaos, sine 6.0 Hz, 6 % · Room 20 % · Mono, glide 60 ms

08 Sound design by attractor

Where each system sounds best, and what to try.

A few habits work on every system:

- Find the timbre with **Axis** first, then set **Chaos**. The axes of one system can sound as different as two oscillators.
- Use **Sub −1 oct** to anchor the pitch when Chaos is high.
- For a sound that lives without sounding random, put the **Wander** on Axis at a slow rate and moderate depth.
- When a sound is almost right but one note feels off, press `Shift` + `FREEZE` to reseed. Each reseed is a new performance of the same patch.
- Let notes settle for half a second before judging the tuning: Auto-tune measures every 200 ms.

8.1 Lorenz

- **Axis Z** is the cleanest and most in-tune: it follows the loops on both wings. *Cold Spring* uses it at Chaos 0 % (ρ 25) for an almost classic tone.
- **Axis X or Y** carry the jumps between wings: irregular low pulses under the pitch. Good for growling leads and evolving pads.
- Low Chaos (ρ 25–35) tends to give long stays on one wing and rarer jumps: a stable tone with occasional events. High Chaos (ρ 60–90) jumps constantly and sounds rough.
- A wide Stereo offset puts a different axis on each side, for example the clean Z on one channel and the jumping X on the other. *Fallout Choir* and *Nuclear Dawn* use 80–90 % for wide pads.
- Wander on Chaos with full depth and a very slow rate sweeps the whole range over many seconds (*Meltdown*).

8.2 Rössler

- **Axis X or Y**: smooth, nearly sinusoidal. **Axis Z**: a spiky pulse train, bright and reedy.
- The bottom of the Chaos range is a period-doubling cascade. Turn Chaos slowly from 0 to about 20 % on Axis X and listen for the sub-octaves appearing one after another, before the tone becomes chaotic.

- Fold suits Rössler well because the x–y signal is smooth: *Scavenger* combines Fold 60 % with Wander on Fold.
- Rössler's long natural period means more sub-steps per sample than the other systems. High notes with all eight voices use more CPU here.

8.3 Chua

- **Axis X** switches between the two scrolls and sounds square and buzzy. **Axis Z** is round and wide. **Axis Y** carries the pitch.
- Chua responds strongly to Radiation, which makes it jump between scrolls much more often. *Geiger* uses 25 %, *Static Storm* 60 %.
- The band-pass filter with high resonance turns Chua into vocal and siren-like sounds (*Siren Field*, *Broken Radio*, *Signal Lost*).

8.4 Duffing

- Always in tune: the best choice for basses and anything that must sit with other instruments.
- **Axis Z** is the driving sine itself, a pure tone. Set Axis between Y and Z, or use Stereo offset, to blend the pure tone with the chaotic response of the spring.
- Low γ tends to keep the spring oscillating in one well; higher γ throws it between the two wells, which you hear as an unstable, rattling low end.
- Combine Sub –1 oct, Mono and Saturation for heavy basses (*Dead Turbine*, *Bunker Bass*).

8.5 Halvorsen

- All three axes have the same level and character, so Axis and Wander on Axis change colour without any change in loudness (*Scrapyard*).
- Short envelopes with Sustain at 0 and Fold around 50 % give bells and plucks (*Rust Bell*, *Tin Can Arp*).
- High Chaos with heavy Fold and Saturation gives hard, cutting leads (*Sawblade*).

09 Installation and troubleshooting

macOS and Windows.

9.1 System requirements

PLATFORM	REQUIREMENT	FORMATS
macOS, Intel	macOS 10.13 or later	AU · VST3 · Standalone
macOS, Apple Silicon	macOS 11 or later	AU · VST3 · Standalone
Windows	Windows 10 or 11, 64-bit, Microsoft Edge WebView2	VST3

9.2 macOS

01

Run the installer

Open the WaveChaos `.pkg` file downloaded from Ko-fi. It installs the three formats; you can untick any of them under *Customise*:

`/Library/Audio/Plug-Ins/Components/WaveChaos.component` (Audio Unit)
`/Library/Audio/Plug-Ins/VST3/WaveChaos.vst3`
`/Applications/WaveChaos.app` (Standalone)

The installer also removes older copies left by hand in your user Library, which would otherwise hide the new version.

02

Allow the installer to open

The installer is not notarised by Apple, so macOS blocks it the first time.

macOS 14 and earlier: right-click (or Control-click) the `.pkg`, choose *Open*, then confirm with *Open*.

macOS 15 and later: double-click the `.pkg` and dismiss the warning. Open *System Settings › Privacy & Security*, scroll down to the message about WaveChaos and click *Open Anyway*, then confirm.

03

Follow the installer

Enter your administrator password when asked.

04

Rescan in your DAW

Restart your DAW so it finds the plugin. In Logic Pro, if WaveChaos does not appear, open *Logic Pro › Settings › Plug-in Manager*, select WaveChaos and click *Reset & Rescan Selection*.

9.3 Windows

01

Copy the plugin

Copy `WaveChaos.vst3` to `C:\Program Files\Common Files\VST3`. Windows asks for administrator permission.

02

Check WebView2

The interface is drawn by Microsoft Edge WebView2. It is part of Windows 11 and is installed on most Windows 10 systems. If the plugin window stays blank, install the WebView2 Runtime from Microsoft.

03

Rescan in your DAW

Restart your DAW or run its plugin scan.

9.4 Troubleshooting and FAQ

No sound (standalone)

If AUDIO OFF is shown, click anywhere on the instrument or press a key: audio can only start after a user action.

Notes are ignored

Check the MIDI channel on page 8. Set it to Omni to accept every channel. In the standalone, the page 8 status line lists the MIDI ports found.

A note is out of tune

Make sure Auto-tune is on (page 2) and give it half a second. Notes so low that fewer than three cycles fit in 200 ms (below about 15 Hz) cannot be measured. Very high Chaos, Radiation or Input drive can keep the pitch moving; Duffing is always in tune.

The sound clicks when I change Attractor

Changing the system restarts every voice on the new attractor. This is expected; change it between notes.

The sound suddenly changes or drops out

If a trajectory escapes, the voice reseeds itself automatically. Press Shift + FREEZE to reseed all voices by hand.

Nothing moves any more

Check the FREEZE indicator: when lit, the orbit loops and the wander is held, so the sound is meant to stay still. Press FREEZE to release it.

The input sample has no effect

Input must be set to Loop or Gate, and in Gate mode a key must be held. Input drive acts on the equations; to hear the sample itself raise Dry input.

My long sample is cut

WaveChaos keeps the first 60 seconds of a file, mixed to mono.

High CPU load

CPU use grows with the number of voices and with pitch, because high notes need more RK4 sub-steps. Rössler and Halvorsen use the most. Reduce polyphony with Mono, or play lower.

Presets reset my volume?

No. Volume, Velocity, MIDI channel, Keys octave, View and the Input controls are global and are never changed by a preset.

10 Specifications and credits

WaveChaos 1.0 · MOD. ET-7

Synthesis	Chaotic oscillators: real-time numerical integration of three-variable ODE systems
Attractors	Lorenz (ρ 25–90), Rössler (c 2.5–12), Chua (α 11–16), Duffing (γ 0.2–0.7), Halvorsen (a 1.27–2.1)
Integrator	Fourth-order Runge–Kutta, one step per sample, 1–16 sub-steps
Pitch	Note sets integration speed via each system's natural period; Auto-tune correction ×0.25–×4 measured every 200 ms; Duffing pitch-locked; Tune ±12 semitones
Polyphony	8 voices or mono legato, glide up to 2 s
Oscillator controls	Chaos, Axis morph X/Y/Z, Stereo offset, Fold, Radiation, Sub −1 oct
Modulation	Wander (sine or smooth random, 0.01–8 Hz) to Chaos, Axis or Fold, with Freeze (holds the wander and loops the orbit); filter LFO (sine, 0.02–20 Hz, ±4 octaves)
Filter	Per-voice stereo state-variable filter, 12 dB/oct, LP/BP/HP, 40 Hz–16 kHz, 30 % key tracking
Envelope	ADSR: attack 1 ms–4 s, decay 10 ms–6 s, sustain 0–100 %, release 10 ms–8 s
Effects	Tanh saturation; ping-pong echo 20 ms–1.2 s with 3.2 kHz filtered feedback up to 92 %; convolution reverb Room 1.2 s, Hall 3.4 s, Ruin 7.0 s; output limiter −3 dB
Input	Audio file (WAV, AIFF, MP3, OGG, FLAC, M4A), mono, up to 60 s; Loop or Gate; forcing drive, ring modulation, dry level
MIDI	Notes with velocity, channel filter Omni/1–16, CC1 Chaos, CC74 Cutoff, CC123 all notes off
Interface	1024 × 600 screen, phase-space display (XY/XZ/YZ/3D), oscilloscope, 4 encoders, 4 buttons, 9 pages
Presets	28 factory presets; user presets saved with the project (plugin) or on the computer (standalone)
Formats	macOS: AU, VST3, Standalone (Intel macOS 10.13+, Apple Silicon macOS 11+). Windows: VST3 (Windows 10/11 64-bit)
Engine	Native C++ port of the WaveChaos engine

Credits

Concept, DSP, sound design and presets: Eric Tripper.

The systems are named after the people who described them: Edward Lorenz, Otto Rössler, Leon Chua, Georg Duffing and Arne Dehli Halvorsen.

WaveChaos is available on Ko-fi. More instruments, music and updates: erictrippermusic.com.

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