Why do I get speed wobble?

The reason why your front wheel starts to wobble violently at certain speeds has perplexed experts for years. *Cyclist* examines the science...

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You’ve crested Alpe d’Huez. You shift into the big ring, adopt the aero position and down you go – 40, 50, 60, 70kmh. Exhilaration here you come. But damn – your handlebars are shaking all over the place. Panic-stricken, you wish you were anywhere else but here. Even playing golf!

Anyone who’s ridden for a number of years has probably experienced the phenomenon known as speed wobble or high speed shimmy. It’s a rare event, but when it strikes it can be terrifying for the unsuspecting. So is it down to bad luck, bad technique, a particular bike, a particular set-up – or can science explain it?

One of the world’s leading experts on bicycle dynamics is Oldham–born Jim Papadopoulos from Northeastern University’s College of Engineering in Boston, USA. He is the co-author of *Bicycling Science* and has penned several academic papers on bike theory, including one in 2013 on the very subject of high-speed bicycle shimmy. If anyone is in a position to unravel the mysteries of speed wobble for us, it’s him... except, by his own admission, it’s not that simple.

‘Unfortunately the science of bicycles is still very primitive, so that we often don’t know how to ask and answer meaningful questions,’ he tells us. In his view, shimmy has been hard to understand because it depends on criteria that until now no one has thought to measure. His paper is the first such record of bicycle shimmy data ever to be published.

‘Shimmy may be identified as a 3–10Hz steering oscillation of the bicycle steering assembly, namely the front fork with the wheel and handlebar. As the front contact describes a sinusoidal path, the steering bearings connecting the front fork to the rear frame displace both laterally and in roll.’

Put simply, the bike wobbles fast, pivoting about the head tube, with the front wheel steering left and right from 3 to 10 times per second. We do know something about the causes too. ‘High speed brings it on, and low torsional stiffness [of the bike] when the wheels are included appears to be a culprit,’ says Papadopoulos.

**Swings and roundabouts**

Damian Harty is senior staff engineer in vehicle and systems dynamics at Polaris Industries. He expands on the subject: ‘Any oscillatory phenomenon hinges on the exchange of energy between two or more forms,’ he says. ‘For a pendulum, it is the potential energy – height above the ground – and kinetic energy – mass in motion. For front end shimmy on a bicycle, it is kinetic energy and a form of potential energy from the angle of the tyre, made by the steering. Tyres make forces due to the angles at which they operate – a bolt-upright, dead ahead tyre makes no lateral forces. The tyre swings around the steer axis to give an angle. Another form of energy involved in this phenomenon is strain energy, which is stored in stretching or bending things. The frame tubes on a bike are like an elastic band and they store energy, releasing it back into the system at the right time to prolong or amplify the motion. Stiffer tubes deflect less,’ Harty adds.

While these oscillations can be suppressed with damping, for instance by reducing a rider’s weight on the saddle, or by holding the handlebars more gently, bike stiffness is a key requirement if you want to stop shimmy.
Jason Rourke of Rourke Bicycles agrees. Rourke designed and built the bike used by Guy Martin in his speed project where he reached 180kmh on Pendine Sands. A framebuilder for over 20 years, his main concern was speed wobble, so Martin’s Rourke was as stiff as a board. ‘Mind you, we were more worried about the wheels,’ he says, ‘so we went as strong as we could. No lightweight spokes and we used Hope hubs. Guy didn’t have one wobble.’

But there’s still the factor of unpredictability. ‘One thing that mystifies people is that sometimes it happens and sometimes it doesn’t,’ says Harty. ‘It’s always there but in a latent way. It just needs something to trigger it off and we’re still not 100% sure what that is.’

**Testing times**

In his recent experiments, Papadopoulos and a team led by Gianantonio Magnani from the Politecnico di Milano used a Colnago C59 size 52S with Fulcrum Racing Zero wheels, Campagnolo Super Record components and an SMP Light 209 saddle, making a total weight of 7kg. An accelerometer was fitted to the stem to measure fore/aft, lateral and vertical movements, as well as roll, pitch and yaw, recording all this at 100 samples per second. On a downhill section, severe shimmy at a frequency of 7.7Hz started at just over 60kmh and lasted for about 15 seconds by which time the speed had reduced to 35kmh due to the road flattening out. When a second rider who was 10kg heavier rode on the same stretch of downhill, they reached speeds of 73kmh with no shimmy at all. ‘This proves that producing shimmy is not solely the property of the bicycle but depends also on the rider, including perhaps the riding technique,’ says Papadopoulos.

The experiments also included variations in other components including tyre construction, tyre pressure, wheel stiffness, saddle stiffness, fork stiffness and stem length. ‘The general conclusion from these tests was that all these parts can affect the shimmy onset speed to some extent, but none of them really change the bicycle-rider tendency to oscillate at a frequency around 7.7Hz,’ adds Papadopoulos. What determines this vibration speed has long been a point of contention. ‘Many people have identified the shimmy frequency with wheel rotational frequency,’ says Papadopoulos. ‘I don’t accept this at all, nor any suggestion that loose or tight headset bearings, or wheel trueness, could be responsible. Shimmy frequency is an elastic property of the bike. Evidently, if the bicycle is “soft” enough (ie elastic enough) torsionally, and if the rider is firmly seated which minimises damping, shimmy will often appear. Probably a torsionally stiffer bike will reduce or eliminate the problem (this might include stiffer wheels), and evidently a somewhat lighter “grip” of the bottom on the saddle, or of hands on handlebar, will make the oscillation disappear.’

And so we come to what a rider can do to counteract shimmy before it gets out of control and potentially causes a crash.

‘Rising a little out of the saddle, or gripping the frame with your knees with a gentle grip on the handlebars can stop the oscillation within a couple of cycles,’ adds Papadopoulos.

And it is possible to practise in a safe environment, something that Papadopoulos recommends. Controllable shimmy can be started deliberately at slower speeds – say from 20kmh upwards – by hitting the head tube sideways with hands off the handlebars. ‘At low speed you can feel quite comfortable riding no-hands with the low-amplitude vibration, and learn how to “turn it up” or “turn it down” by weight shift, or by touching the handlebars. Practice makes perfect.’

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