we found a positive relationship between male display intensity and startle rate ($\beta_{\text{response}} = -0.92$, $P < 0.001$; $\beta_{\text{intensity}} = 0.51$, $P < 0.028$; $r^2 = 0.68$, $F_{2,10} = 10.71$, $P < 0.003$).

We predicted that the most successful males would be those who produce high-intensity displays without startling females. Indeed, we found a positive correlation between male display intensity in robot courtships and male success in natural courtships (Fig. 2c), and a negative relationship between startle rate and male courtship success (Fig. 2d), with both factors contributing to male courtship success when considered together ($\beta_{\text{intensity}} = 0.55$, $P < 0.004$; $\beta_{\text{startle}} = -0.57$, $P < 0.003$; $r^2 = 0.65$, $F_{2,14} = 13.23$, $P < 0.0006$).

Our results indicate that although female satin bowerbirds prefer intensely displaying males, successful males do not always display at maximum intensity — instead, they modulate the intensity of their display in response to female signals, to remain attractive without threatening the females. In satin bowerbirds — and perhaps in other species in which variation in sexually selected traits has not yet been examined in detail — male courtship success may depend on both an attractive display and the intrinsic ability to modify these in response to female signals.

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Laser technology

Measuring huge magnetic fields

Huge magnetic fields are predicted[1–4] to exist in the high-density region of plasmas produced during intense laser–matter interaction, near the critical-density surface where most laser absorption occurs, but until now these fields have never been measured. By using pulses focused to extreme intensities to investigate laser–plasma interactions[5], we have been able to record the highest magnetic fields ever produced in a laboratory – over 340 megagauss – by polarimetry measurements of self-generated laser harmonics.

Because harmonics of the laser are generated at the critical-density surface and subsequently propagate isotropically out of the dense region[6], we have found that measuring the final polarization of these harmonics is a powerful way to find out the magnitude of the magnetic fields through which they travel. The use of self-generated laser harmonics is particularly convenient because these are produced at precisely the same time as the magnetic fields are generated and propagate so that their **k** vectors are perpendicular to azimuthal magnetic fields in the plasma — which greatly simplifies data interpretation. In our experiments, we use the propagation properties of lower-order harmonics (that is, the third, fourth and fifth harmonics).

These results were obtained with the Vulcan laser system (wavelength 1.054 μm, pulse energy up to 90 J, pulse duration about 1 picosecond). The beam was *p*-polarized and focused to a maximum intensity of 9×10^{19} W cm^{-2} onto a thin solid target (0.1–1.0 mm). The polarization components of the emitted laser harmonics were measured by using high-dynamic-range, charge-coupled-device arrays as detectors.

When an electromagnetic wave propagates in a magnetized plasma with its **k** vector perpendicular to **B**, the extraordinary wave (*x*-wave; that is, with an electric field vector perpendicular to the magnetic field) can experience cut-offs and resonances (Fig. 1a). Cut-offs occur when the plasma index of refraction is equal to zero, and resonances when the index approaches infinity. The *x*-wave is reflected when it encounters a cut-off and is absorbed in a resonance. For example, the cut-offs for the fifth, fourth and third harmonics occur at 460, 340 and 220 megagauss, respectively, for a density of $n_e = 2.4 \times 10^{21}$ cm^{-3} (the relativistically corrected critical density). Resonances occur at higher magnetic fields than cut-offs. The ordinary (*o*) wave (with **E** parallel to **B**) is unaffected by the magnetic field — implying that if a field larger than the cut-off field exists in the plasma, then only the ordinary wave is able to propagate to the detector and therefore is the only one observable.

This is what we find for the highest-intensity shots. Figure 1b shows the ratio of *p*-component (*x*-wave) to total emission (*x*-wave plus *o*-wave) for both the third and fourth harmonics for various incident laser intensities. At high intensities, the *x*-wave cut-offs are definitely observed, implying the existence of a minimum magnetic field of 340 megagauss in the plasma; no cut-offs were seen for the fifth harmonic. This indicates that the peak magnetic field is below 460 and above 340 megagauss at intensities of about 9×10^{19} W cm^{-2}. Such fields are more than an order of magnitude larger than any previously observed in the laboratory[7–9]. These cut-offs were consistently reproducible in our experiments — but only at the highest laser intensities.

The magnitude of the magnetic fields generated in this way could soon approach those needed for testing astrophysical models of neutron stars and white dwarfs[10].

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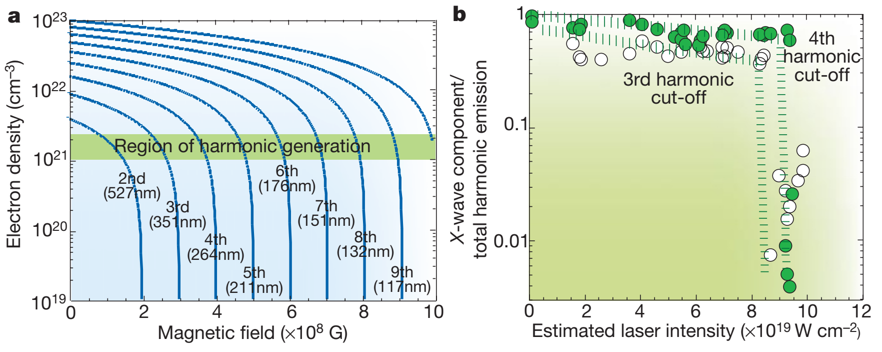

Figure 1 Laboratory measurement of magnetic fields greater than 340 megagauss. **a,** Plot of *x*-wave cut-offs for various harmonics (second, third, and so on) of 1.054-μm radiation in terms of plasma electron density and magnetic field. **b,** *X*-wave/total harmonic emission of third harmonic (hollow circles) and fourth harmonic (filled circles) for a series of laser shots.

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