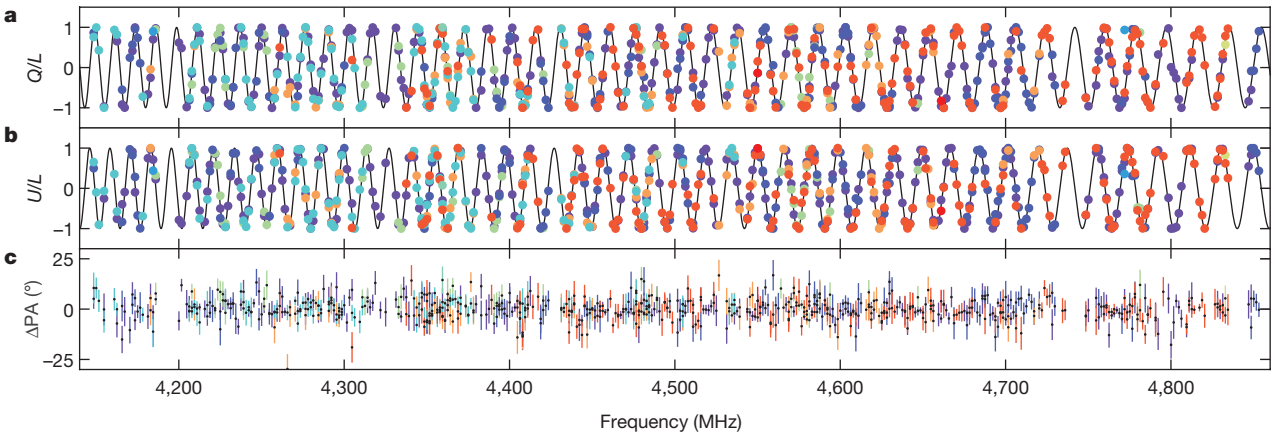

Figure 2 | Faraday rotation in the bursts. a, **b**, Variations of the Stokes parameters Q (**a**) and U (**b**) with frequency, normalized by the total linear polarization ($L=\sqrt{Q^2+U^2}$), for the six brightest Arecibo bursts detected on modified Julian date 57,747. Different bursts are plotted using different colours. Only data points with signal-to-noise ratio higher than 5 are plotted and do not include uncertainties. The black lines represent the best-fitting Faraday rotation model for the global values reported in Table 1. **c**, Difference between calculated and measured polarization angles (ΔPA) with 1σ uncertainties around the central values, which are indicated with black dots.

rotation measure (below about 50 rad m^{-2}) and polarization angle (lower than approximately 10°) between bursts. The GBT data are not well modelled by the use of a single $\mathrm{PA}_{\infty}^{\mathrm{global}}$ value, but this could be an instrumental difference or reflection of the higher observing frequency. The near constancy of the polarization angle suggests that the burst emitter has a stable geometric orientation with respect to the observer. A linear polarization fraction higher than about 98% at a single rotation measure constrains turbulent scatter[19] as $\sigma_{\mathrm{RM}}<25$ rad m^{-2} and the linear gradient across the source as $\Delta_{\mathrm{RM}}<20$ rad m^{-2}, and there is no evidence of deviations from the squared-wavelength (λ^2) scaling of the Faraday rotation effect. Analysis with the RM Synthesis technique and the deconvolution procedure RMCLEAN also implies a 'Faraday-thin' medium (see Methods).

In the rest frame, the host galaxy contributes a dispersion measure $\mathrm{DM_{host}}\approx 70$–$270$ pc cm^{-3} to the total dispersion measure of the bursts[8]. Given $\mathrm{RM_{src}}$, this corresponds to an estimated line-of-sight magnetic field $B_{\parallel}=0.6f_{\mathrm{DM}}$–$2.4f_{\mathrm{DM}}$ mG. This is a lower-limit range because the dispersion measure contribution that is related to the observed rotation measure ($\mathrm{DM_{RM}}$) could be much smaller than the total dispersion measure contribution of the host ($\mathrm{DM_{host}}$, dominated by the star-forming region), which we quantify by the scaling factor $f_{\mathrm{DM}}=\mathrm{DM_{host}}/\mathrm{DM_{RM}}\geq 1$. For comparison, typical magnetic field strengths within the interstellar medium of our Galaxy[20] are only about 5 μG.

We can constrain the electron density, electron temperature (T_{e}) and length scale (L_{RM}) of the region causing the Faraday rotation by balancing the magnetic field and thermal energy densities (Extended Data Fig. 6). For example, assuming equipartition and $T_{\mathrm{e}}=10^6$ K, we find a density of $n_{\mathrm{e}}\approx 10^2$ cm^{-3} on a length scale of $L_{\mathrm{RM}}\approx 1$ pc, comparable to the upper limit of the size of the persistent source[10].

A star-forming region, such as that hosting FRB 121102, will contain H II regions of ionized hydrogen. Although very compact H II regions have sufficiently high magnetic fields and electron densities to explain the large rotation measure, the constraints from $\mathrm{DM_{host}}$ and the absence of free–free absorption of the bursts exclude a wide range of H II region sizes and densities[21] for typical temperatures of 10^4 K.

The environment around a massive black hole is consistent with the n_{e}, L_{RM} and T_{e} constraints[22], and the properties of the persistent source are compatible with those of a low-luminosity, accreting massive black hole[10]. The high rotation measure towards the Galactic Centre magnetar[23] PSR J1745−2900 (Fig. 3), $\mathrm{RM}=-7\times 10^4$ rad m^{-2}, provides an intriguing observational analogy for a scenario in which the bursts are produced by a neutron star in the immediate environment of a massive black hole. However, the bursts of FRB 121102 are many orders of magnitude more energetic than those of PSR J1745−2900 or any Galactic pulsar.

An alternative description of FRB 121102 has been proposed by a millisecond magnetar model[8,10,13]. According to that model, one would expect a surrounding supernova remnant and nebula powered by the central neutron star. The n_{e}, L_{RM} and T_{e} constraints are broadly compatible with the conditions in pulsar-wind nebulae, but dense filaments like those seen in the Crab Nebula[24] may need to be invoked to explain the high and variable rotation measure of FRB 121102. In a young neutron star scenario, an expanding supernova remnant could also in principle produce a high rotation measure by sweeping up surrounding ambient medium and progenitor ejecta[25]. A more detailed discussion of these scenarios is provided in Methods, and more exotic models also remain possible[26].

Regardless of its nature, FRB 121102 clearly inhabits an extreme magneto-ionic environment. In contrast, Galactic pulsars with comparable dispersion measures have rotation measures that are

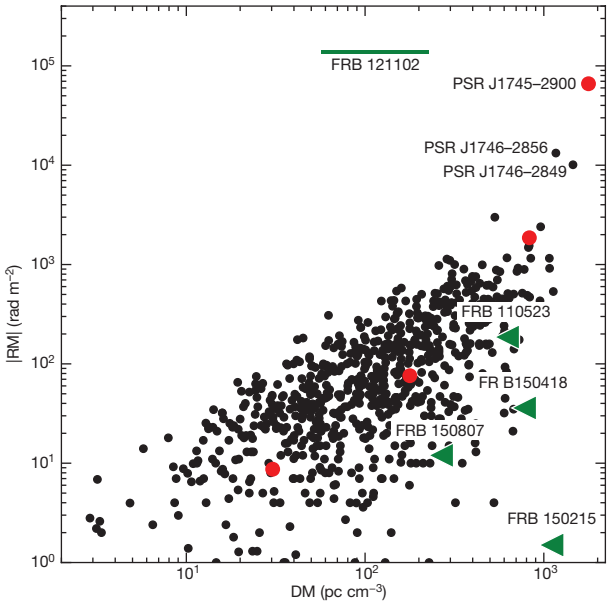

Figure 3 | Magnitude of rotation measure versus dispersion measure for fast radio bursts and Galactic pulsars. Radio-loud magnetars are highlighted with red dots, while radio pulsars and magnetars closest to the Galactic Centre[30] are labelled by name. The green bar represents FRB 121102 and the uncertainty on the dispersion measure contribution of the host galaxy[8]. Green triangles are other fast radio bursts with measured rotation measure; here the dispersion measure is the upper limit of the contribution from the host galaxy.