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Low Jitter (<1ps) Passively Modelocked Fibre Soliton Laser

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Abstract

We have studied the temporal jitter of a harmonic passively modelocked fibre soliton laser. Jitter as low as 600 fs has been observed for 700 fs solitons at a repetition rate of 463 MHz.

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Summary

Passively modelocked fibre soliton lasers have become attractive as sources for laboratory and telecommunications applications due to their properties of simplicity, tunability and subpicosecond operation. However, such lasers tend to suffer from instability in the repetition rate which for many applications is unacceptable. Recently though, stable harmonic passive modelocking was observed in a ring laser configuration [1]. In this paper, we present a detailed experimental study of time jitter in such a laser and demonstrate that a jitter as low as 600 fs can be obtained.

The laser used in our experiments has been described elsewhere [1] and contains a length of Er/Yb codoped fibre, a length of standard telecom fibre, a polarising isolator and two sets of polarisation controllers. The amplifier is pumped at 1064 nm by a Nd:YAG laser through a WDM. Modelocking of the laser is achieved by adjustment of the polarisation controllers and, at certain positions of the polarisation controllers, a harmonic passively modelocked regime was observed. By changing the pump power we were able to change the repetition rate of the laser.

The time jitter is measured by analyzing the rf spectrum of the laser output intensity [2]. Figure 1 shows the jitter measured as a function of the pulse repetition frequency for a laser cavity of fundamental frequency 5.78 MHz (total length 35 metres) and pulsewidth 0.8 ps. The graph shows a strong oscillatory behaviour and a general tendency for the jitter to decrease at frequencies around 500 MHz. Note that we observed the same general behaviour for several different cavity lengths as well.

By changing the length of the laser cavity we were able to study the jitter for different pulsewidths. The lowest jitter of 600 fs was observed for 0.7 ps (fwhm) pulses at a repetition frequency of 463 MHz in a laser cavity of fundamental frequency 11.0 MHz (total length 18 metres). The third order rf spectrum at 1388 MHz is shown in figure 2 and the corresponding optical spectrum in figure 3. The ratio of jitter to pulse separation is $3x10^{-4}$. In addition, the sidebands in the optical spectrum produce peaks in the rf spectrum which enable an accurate measurement of the total cavity dispersion to be made.

The experimental observations suggest that the stability of the laser is dependent on the long range soliton interaction due to transverse acoustic wave excitation by electrostriction. As shown in [3] the spectrum of the acoustic response peaks close to 500 MHz. For repetition rates around this frequency, the pulse separation is close to the acoustic response time of the fibre. Therefore the pulse interaction is strongest and results in the lowest jitter. Also decreasing the pulsewidth increases the soliton pulse energy which increases the magnitude of the electrostrictional response. Therefore, using a shorter cavity to reduce the pulsewidth should improve stability as well.

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In conclusion, we have experimentally studied the temporal jitter of a harmonic passively modelocked fibre soliton laser and demonstrate that such a laser can produce pulses as short as 700 fs with time jitter below 600 fs at a repetition rate of 463 MHz.

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References

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Figure Captions

1. Jitter as a function of repetition frequency for a total cavity length of 35 metres.

2. Third order rf spectrum for repetition frequency 463 MHz and cavity length 18 metres, indicating 600 fs jitter.

3. Optical spectrum of solitons for repetition frequency 463 MHz and cavity length 18 metres. Pulsewidth=0.7 ps (fwhm). Estimated peak power=30 W.

Fig 1

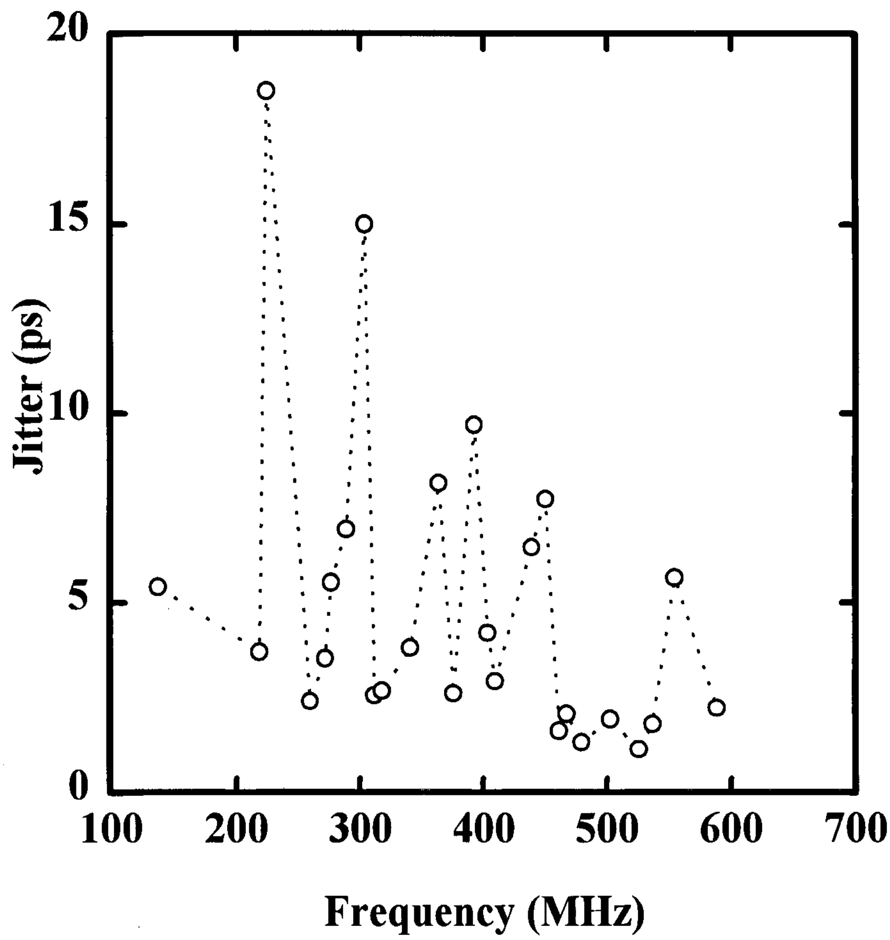
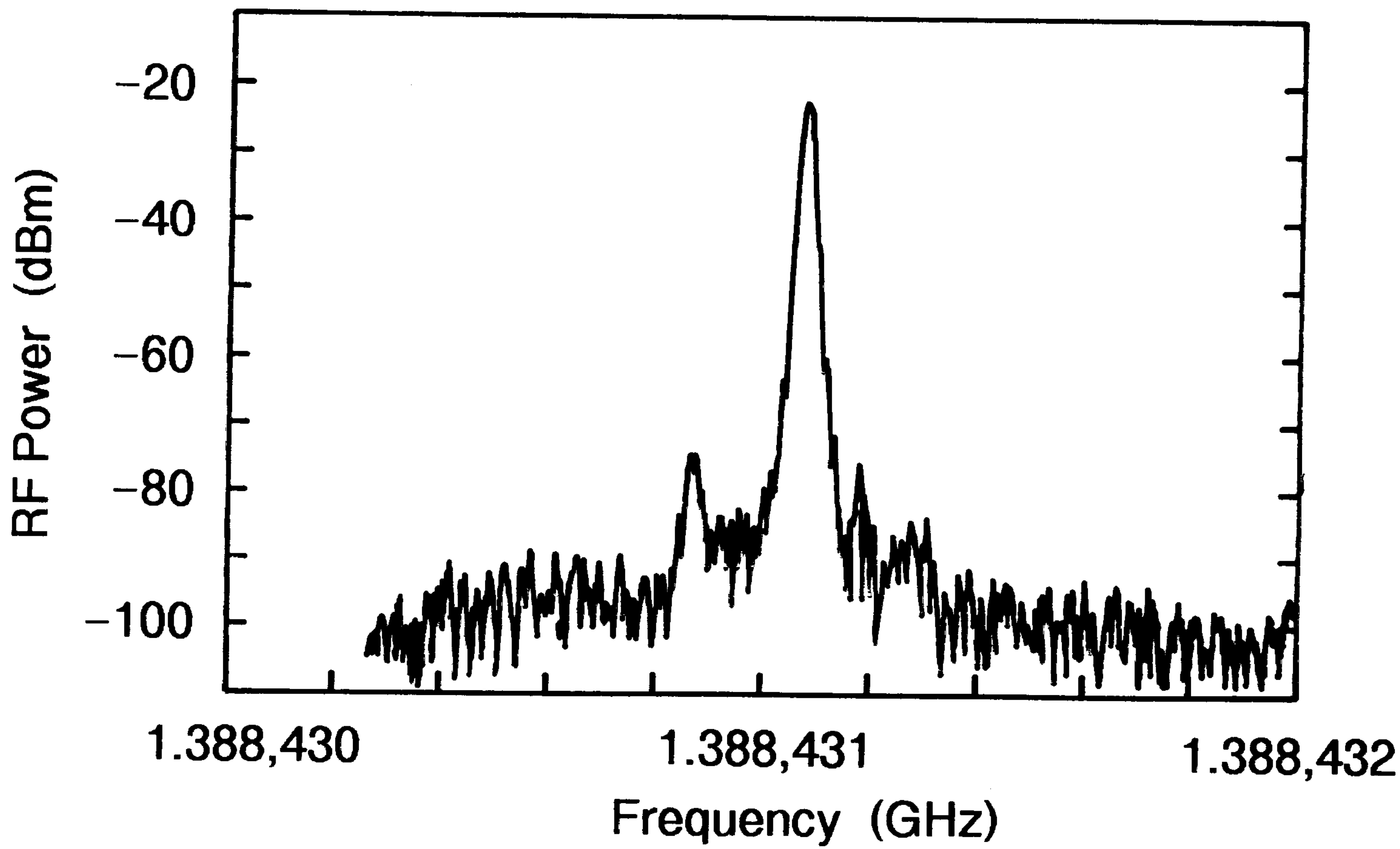


Fig 2



RF Power (dBm)
-20
-40
-60
-80
-100
1.388,430
1.388,431
1.388,432
Frequency (GHz)

Fig 3