FREQUENCY STABILISATION OF DIODE LASERS

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1 INTRODUCTION

Recent developments of theoretical considerations on coherent optical fibre transmission systems (1-3) open a very wide research field, and many experiments are presently carried out in many laboratories to investigate the various devices needed to perform a coherent optical link. We will first give in section 2 a brief summary of the expected performances of such systems and review the requirements on the various components of the link (laser, isolator, modulator, fibre, optical amplifiers, signal/local mixer, demodulator, ...).

In section 3 we will concentrate on the transmitter and local oscillator, and more precisely on the lasers which must have special spectral properties (as compared to direct detection), such as a very stable mean frequency and a very narrow spectral linewidth, and we will deal with the basic phenomena involved in spectral linewidth of the lasers. Section 4 reports experimental results recently obtained in various laboratories.

2 COHERENT OPTICAL FIBRE TRANSMISSION SYSTEM

2.1 Special features of coherent transmissions

Let us briefly review the main advantages of coherent type detection systems:

(i) The receiving level is limited only by the shot noise provided that the local oscillator has sufficient power at the
receiver to dwarf all other detection noise contributions. This corresponds to the quantum limit of detection.

(ii) Advanced signal processing techniques such as frequency or phase modulation and demodulation can be used.

(iii) The highly selective optical coherent detection improves the noise performances of optical amplifiers and allows to use cascaded on-line amplifiers (for more details on this subject, see in this volume the contribution of J.C. SIMON entitled: "Light amplifiers in optical communication systems").

(iv) Spectral multiplexing with fine frequency separation allows to fully exploit the lowest loss transmission window of optical fibres.

All these points lead to expected spacing between repeaters of over 100 km at 1.6 μm and to electronic regenerative repeaters spans on the order of 10³ to 10⁴ km.

2.2 The coherent type link

Fig. 1 shows the basic configuration of a coherent type optical fibre system. The transmitter local oscillator generates a stable optical carrier wave at nominal frequency  𝜔ₛ. The modulator shall impress data onto the carrier wave either by amplitude, frequency or phase modulation. Coherent detection requiring a very stable mean frequency and a very narrow linewidth, the two functions: signal oscillation and modulation, will presumably be separated. An optical isolator will likely be unavoidable to prevent spurious optical power reflected back from disturbing the delicate spectral properties of the source. Modulation can be performed either with an external (phase, frequency or amplitude) modulator or through an injection locked semi-conductor laser which could also be frequency-, phase- or amplitude-modulated. The transmitter can include an optical amplifier if the output signal level if far lower than the stimulated Brillouin scattering (SBS) threshold. The transmission line comprises a single mode fibre cable and possibly on-line amplifiers based on laser diodes. The receiver local oscillator is similar to the transmitter local oscillator with a frequency  𝜔ₗ which is different from  𝜔ₛ in the case of heterodyne systems. The mixer ensures that the phase fronts of both signal and local waves are well matched and combined, and eventually matches the two states of polarization (SOP), even if the SOP of the received wave varies. Due to the quadratic mechanism of photodetection, the photocurrent has a component proportional to the signal electromagnetic field. The decoder is a classical microwave of radio-link receiver designed for demodu-