Study of He-Ne Laser Beam Propagation Through Air and Pure, Salt (Still and Turbulence) Water

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Abstract :

This papers ,study properties of the laser beam in the different condition, By using optical system consist of the (He- Ne) laser ((λ =632.8nm , p=1.04mw)), the parameter beam laser(spot, shape, intensity) were study and also study the attenuation and turbulence for the laser mentioned above and with following environmental condition.(1) in the air (2) in the pure ,slate (seawater)water with concentration 10^{-5}Ml (still, turbulence) at different distance. Measurement were obtained by using a CCD camera and silicon detector type(Silicon PIN) in fast response (.0.4-0.7)A/W, absorption coefficient value of all cases was calculated.
Keywords:- laser beam, CCD camera, optical detector

الخلاصة:

تم في هذه البحث دراسة خواص حزمة الليزر لمنظومه ليزرية وبظروف مختلفة عمليا وتم ذلك باستخدام منظومة بصرية احتوت على ليزر الهليوم نيون ذو الطول الموجي (λ =632.8nm) والقدرة (p=1.04mw) حيث تم دراسة معلمات حزمة الليزر(البقعة، الشكل، الشده) ومن ثم دراسة التوهين والاضطراب لليزر وبظروف بيئية مختلفة هي: اولا: دراسة خواص الحزمة الليزرية في الهواء وعلى مسافات متغيرة .ثانيا: دراسة خواص الحزمة الليزرية للمنظومة في الماء النقي والماء المالح وبتركيز ٥-١٠ (ماء البحر) الساكن والمضطرب وعلى مسافات متغيرة. وتم الحصول على القياسات باستخدام (CCDC AMERA) وكاشف سيليكون نوع (PIN) وباستجابة سريعة A/W(0.7-0.4). وقد قيست معاملات الامتصاص لكل الحالات.
الكلمات المفتاحيه:- حزمة الليزر، CCD كاميرا، كاشف بصري

1-Introduction:

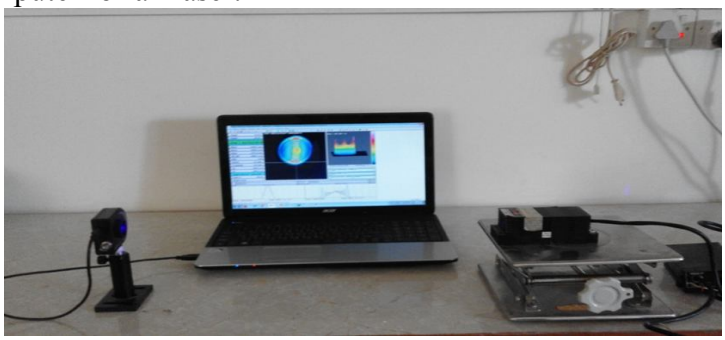
Laser technology is widely used in various fields of human activities, for its excellent monochromatic, coherence and directionality[Gould,R,1959]The most widely encountered type of laser beam has a Gaussian intensity distribution at planes normal to the propagation direction. A Gaussian laser beam is completely characterized for all distances from the source by only two parameters, i.e., the minimum beam waist radius and the location of the minimum waist[Kogelnik and Li, 1966]Laser beams with intensity profiles other than Gaussian or with specific multimode distributions have attracted much interest with applications in laser processing, lithography, fiber injection, medical applications, and laboratory research [Dickey *et al*., 2000;Dickey *et al*., 2005]. More accurate and fast measurements of the laser beam width are obtained with a CCD camera that provides a direct and real time view of the laser beam profile[Kelly *et al*.,2003]

Many lasers emit beams with a Gaussian profile, in which case the laser is said to be operating on the fundamental transverse mode, or "TEM_{00} mode" of the laser's optical resonator. beam shaping is the process of redistributing the irradiance and phase of a beam of optical radiation. The irradiance distribution defines the beam profile, such as, Gaussian, multimode, annular, rectangular, or circular. The phase of the output beam determines its propagation properties[Liu,2006].The passage of a coherent electromagnetic beam through a pure medium in turbulence results in a change of light velocity which in turn causes distortion in intensity and phase of the

beam. Propagation of optical waves through random media such as the atmosphere, the ocean, and biological matter, is very important in many applications such as optical communications and astronomical imaging .In these situations, the temporally and spatially varying media change the amplitude and phase of the propagating optical fields in both time and space. These effects can cause attenuation or loss of the transmitted information and energy because of their directionality and high energy concentration, laser beams are widely used in modern optical communications in , remote sensing, and laser weapon systems. The performance of all these systems is limited by turbulence effects.

2- Experimental set up

Two methods were used to determine the spot , shape and the intensity of laser beam 1- in air ,2- in pure and salt(still, turbulence)water, by using He-Ne laser system (λ =632.8nm , p=1.04mw) the used technic shown in figure(1), CCD camera was placed in front of the laser beam that was focused at the center of the camera at different distance (10,20,30,40)cm , the best spot was chosen at the presence of the software in computer for all laser.



Figure(1)Experimental set up of the laser beam in air

2- in pure and salt (10^{-5})(Still, turbulence)water

Use the same systems in the first method to measure spot, shape, and intensity. Use a glass tank dimensions(d1=150cm ,d2=15cm) is placed on one side the laser and in the second side optical window B7 type diameter 30mm, transmission 0.8 placed exactly in front of the CCD camera, After filling the glass tank with pure water (still) the beam laser was passes into the water and focused at the center of the camera,used electric motor was flow rate 3(L/min) for generate turbulence in the pure water , as shown in figure (2)., the best spot of the laser beam was measured at the presence the software in computer for all lasers at different distance (10,20,30,40) cmthis experiment was repeated on the salt water (still, turbulence) concentration 10^{-5}Ml.

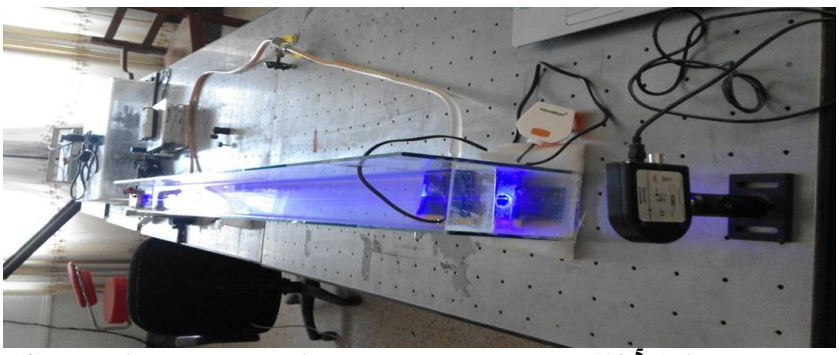


Figure (2)Experimental setup in pure and slate water(10^{-5})(still and turbulence)

Results and Discussion :

Figure (3)represents absorption spectral for pure and salt water where less absorbance is noticed in the visible region. the maximum absorbance was in salt water, As Shows the figure(3), that pure and salt water is transparent for visible light where not there absorption peak in range (180-680) consist part from UV and visible light the value of absorption coefficient in pure (still ,turbulence)water(0.0014, 0.0021)cm^{-1} while in slate (still ,turbulence) water(0.0021,0.0033)cm^{-1}respectively.

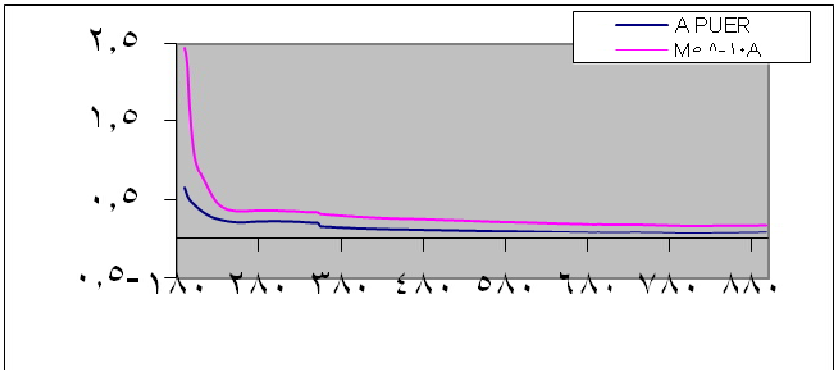


Figure (3) absorption spectral for pure and slate water

1- He- Ne laser- in air:

the Results have shown that the spot beams relatively regular circuit and the shape of the distribution intensity was Gaussian shape at differentdistance (10, 20, 30, 40)cm,While the intensity (peak values) changed with different distance (10,20,30,40) cm, and decrease intensity with increase the distance,as shown in figure(3)(a,b,c,d),

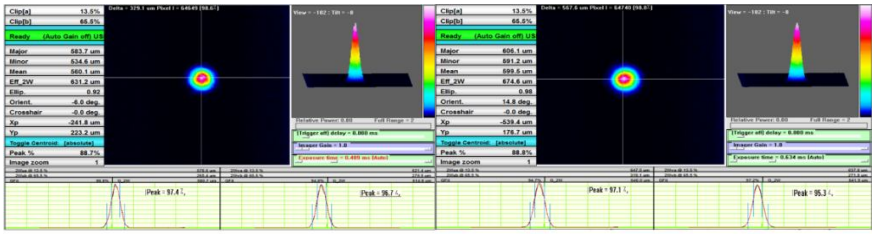


figure (3)(a, b)show laser beam spot profile He-Ne at distances(10,20) cm in air

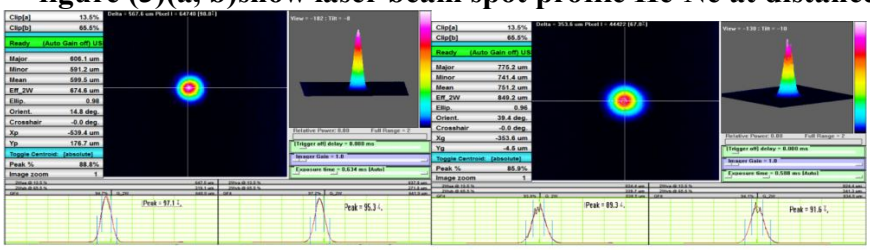


figure (3)(c ,d)show laser beam spot profile He-Ne at distances(30,40)cm in air

2-He-Ne laser in pure(still)water :

The result has shown that spot different on the circular shape when using pure still water, and appeared a little difference in the shape of intensity distribution for Gaussian shape, it was noticed that the intensity change wasn't regular at different distance, as shownin figure(4)(a,b,c,d).

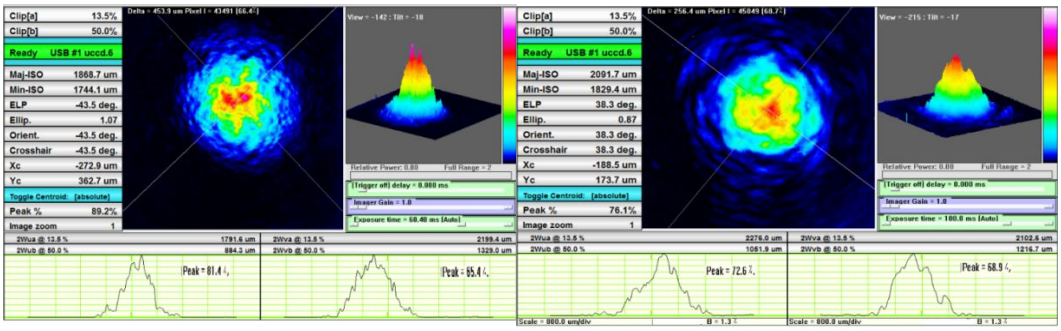


figure (4)(a, b,) show spot profile He-Ne at distances(10,20) cm in still water

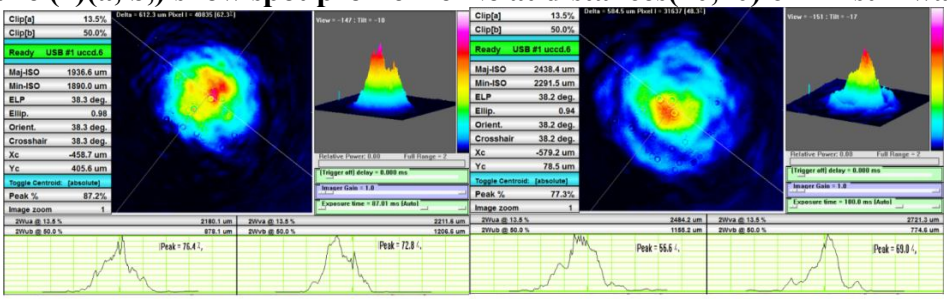
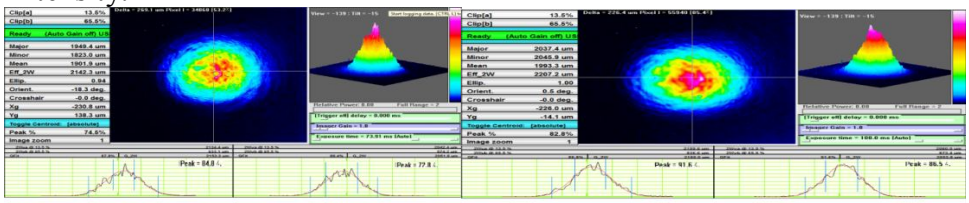


Figure (4)(c ,d) showspot profile at distances(30,40) cm in pure water(still)

3- He-Ne in pure (turbulence) water

A big difference in the shape of the spot observed In pure troubled water case and appeared a little difference in the shape of intensity distribution for Gaussian shape intensity.



figure(4)(a, b,) show spot profile at distances(10, 20) cm in pure turbulencewater

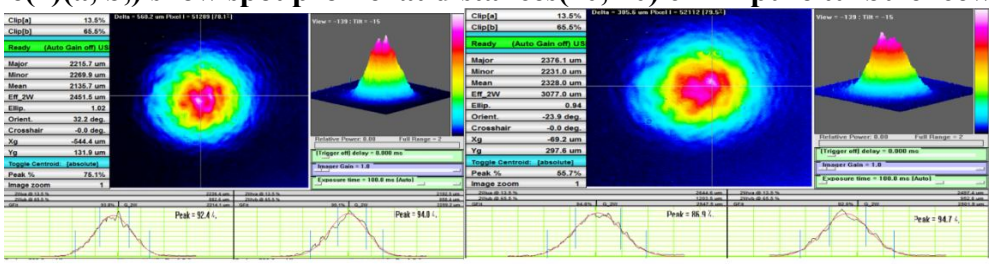


figure (4)(c, d,) show spot profile He-Ne at distances(30, 40) cm in pure turbulence water

4- He-Ne in slate water (still)

In fig (5) The spot changed for circler shape and appeared a little difference in the shape of intensity distribution for Gaussian shape intensity, and the value of intensity was change (74,24.3, 96.2, 79.8)%.

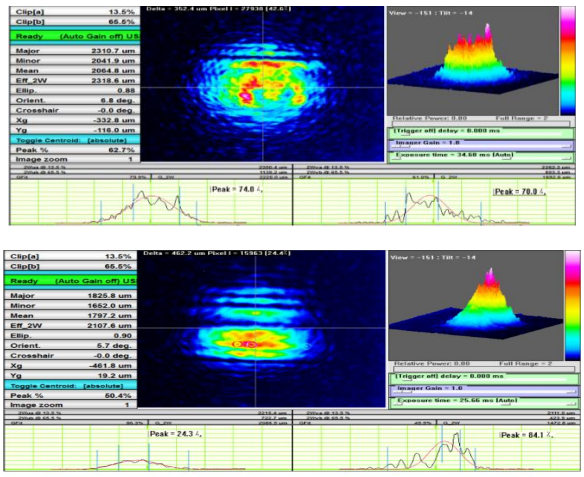


figure (5)(a) show laser beam spot profile He-Ne at distances(10, 20) cm in slate still with concentration($^{10-5)}$ Ml water

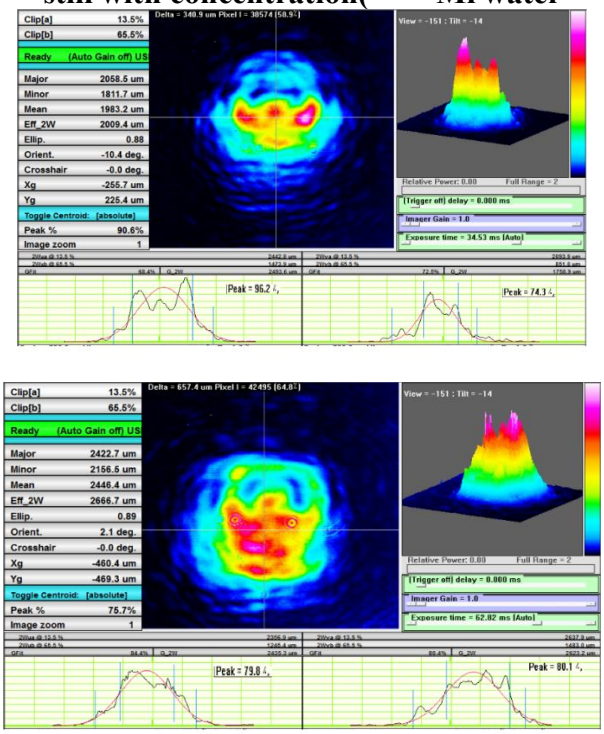


figure (5)(b) show laser beam spot profile He-Ne at distances(30, 40) cm in slate still with concentration(10^{-5}) water

5- He- Ne in salt water turbulence with concentration 10^{-5}Ml

In case salt still water. The biggest change of the beam laser spot was, while it was noticed the intensity wasn't regular at different distance.

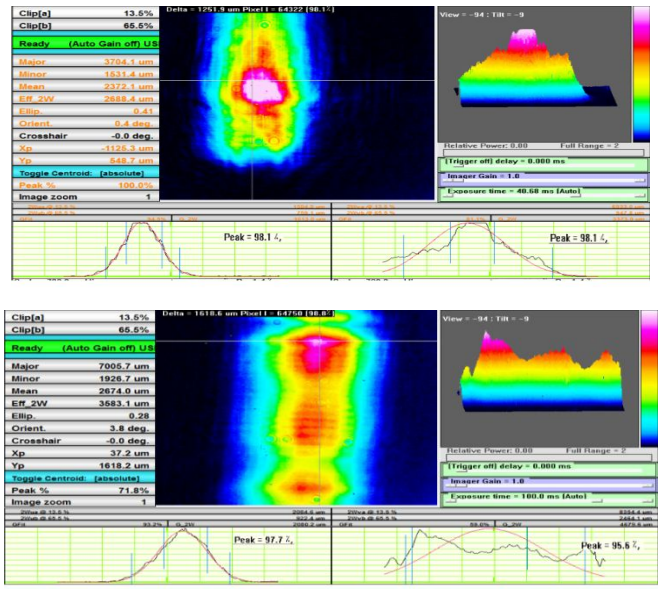


figure (6)(a, b) show laser beam spot profile He-Ne at distances(10, 20) cm in slate turbulence water with concentration(10^{-5})

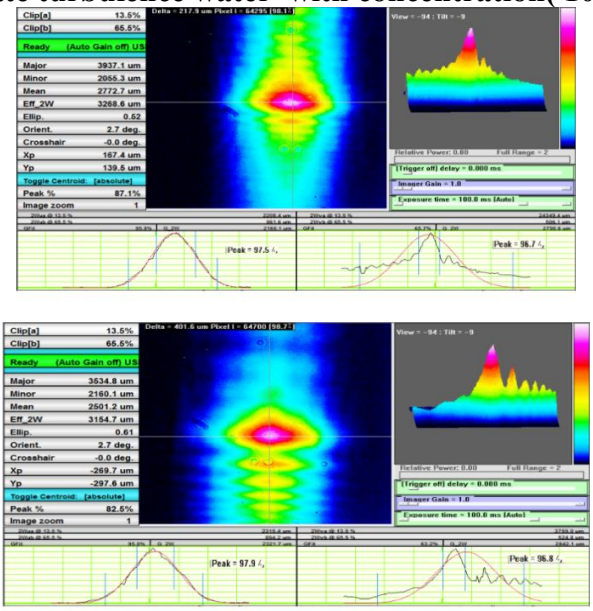


figure (6)(c, d) show laser beam spot profile He-Ne at distances(30, 40) cm in slate turbulence water with concentration(10^{-5})Ml

Conclusion

1-The result has shown that the spot beams relatively regular circuit and the shape of the distribution intensity was Gaussian shape of He-Ne laser in air. While the peak values changed with different distance (97.4,97.1,97.1,89.3)%, and decrease intensity with increase the distance.

2- While different spot on the circular shape when using pure, slate (turbulence) and appeared a little difference in the shape of intensity distribution for Gaussian shape intensity and the biggest change was with slate, turbulence. it was noticed the intensity wasn't regular at different distance.

3- The absorptioncoefficient value of the three cases was changed according to type of case.

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